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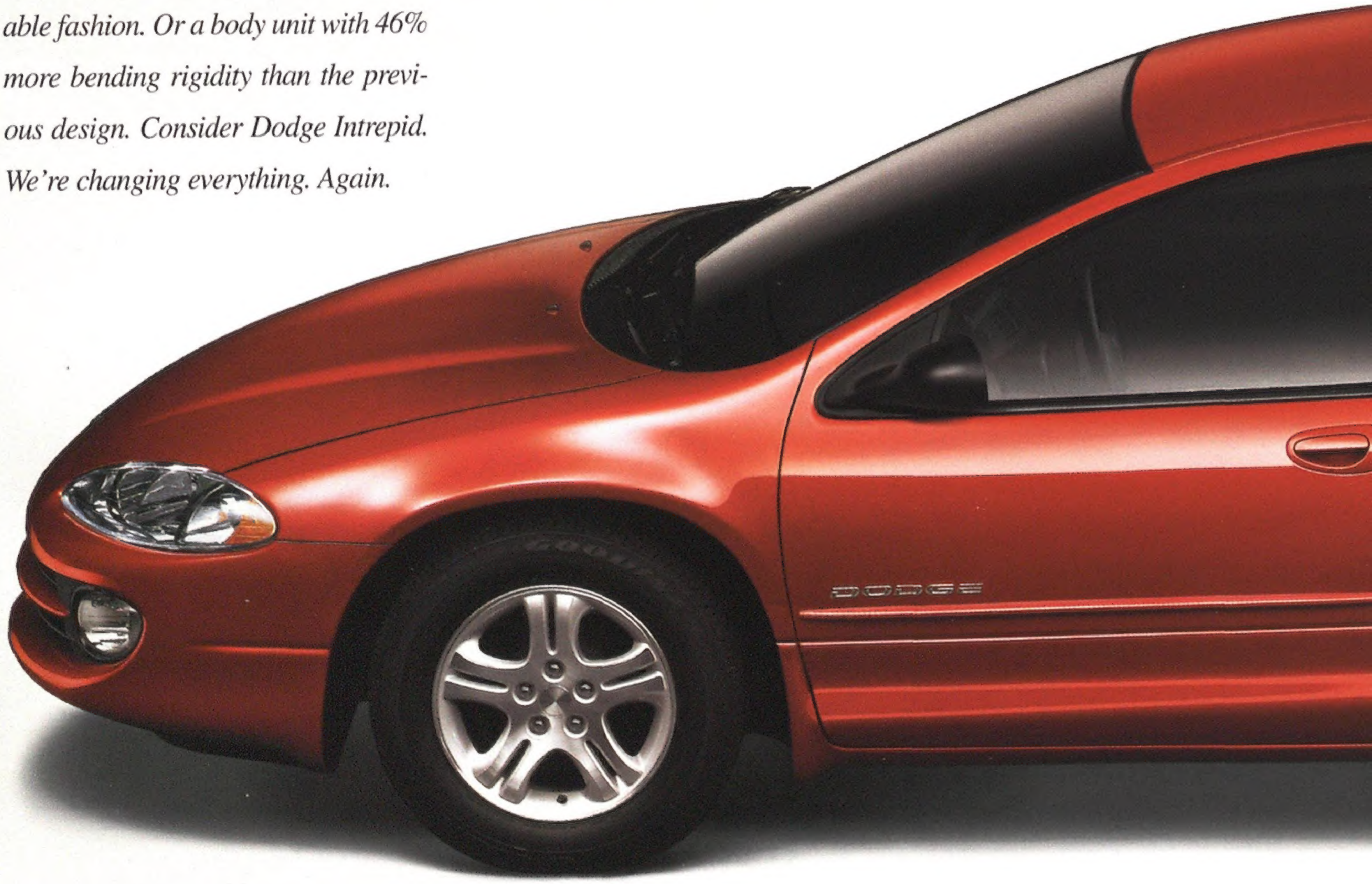


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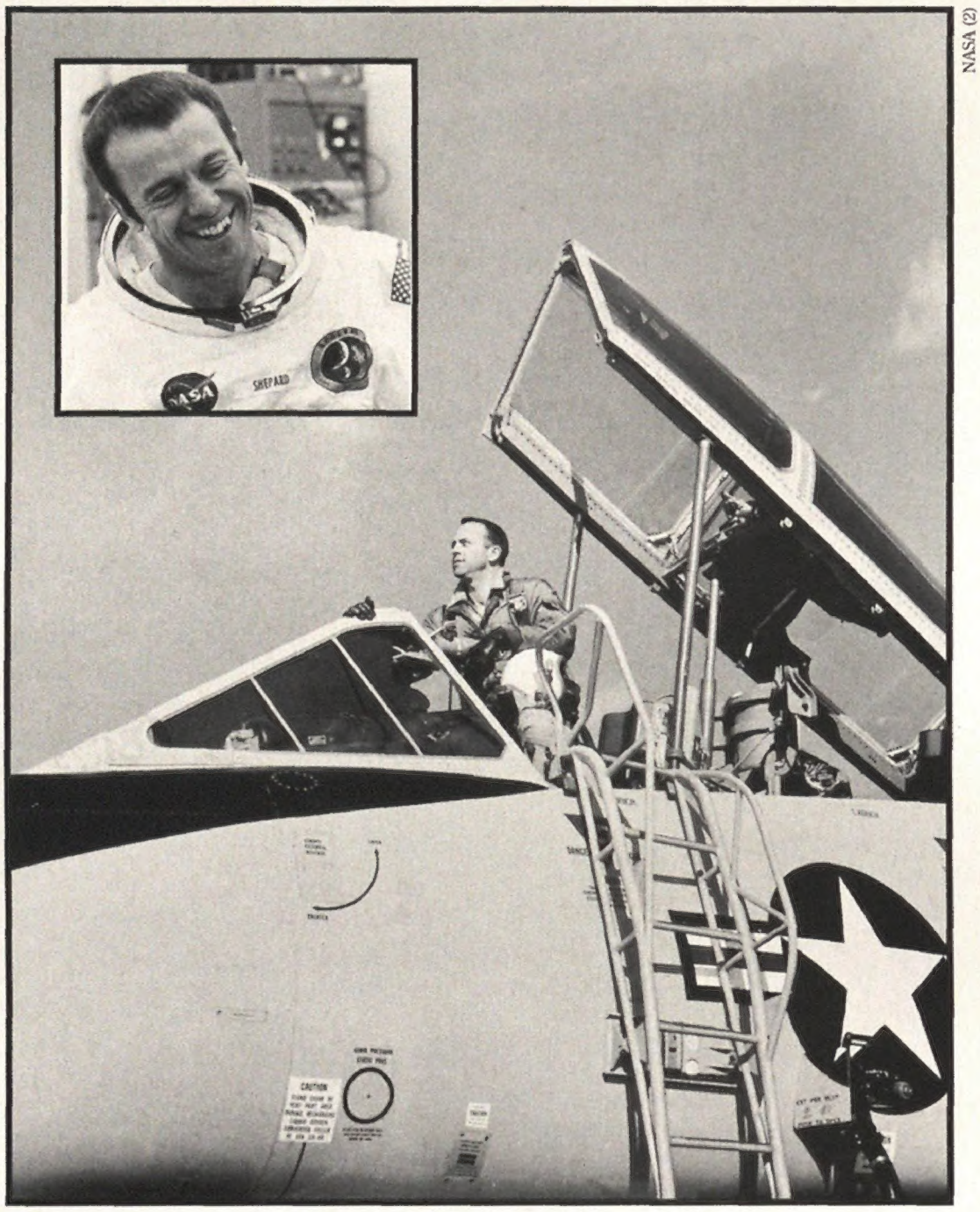



NASA (2)

## Birth of the Cool

It was Wernher von Braun who kept Alan Shepard from becoming the first man in space. In March 1961, with the new Mercury spacecraft all buttoned up and ready to fly and the astronauts raring to go, NASA's chief rocketeer insisted on one last test of his Redstone booster—even though engineers calculated the chance of astronaut survival to be a solid 98 percent. Shepard never forgave what he viewed as a failure of nerve that let Yuri Gagarin steal his and America's triumph. "We had 'em by the short hairs," he lamented in 1994, "and we gave it away."

What, then, did Shepard's 15-minute cannon shot, which followed Gagarin's more impressive orbital flight by 23 days, really accomplish? For one thing, it inspired the new president, John Kennedy, to set the nation on a course for the moon. And it gave us the image of the cool astronaut, an icon as powerful as any in this century.

Shepard's cool owed much to his experience as a Navy test pilot. At Patuxent River Naval Air Station in Maryland, he had helped wring out the F8U Crusader, F11F Tiger, F5D Skylancer, and other jets. He had also faced danger as a fighter pilot. In the early 1950s he landed an F2H Banshee on a carrier off the Korean coast, at night, in a storm, with his navigational system out. Military pilots, though, don't normally have a nation's self-esteem hanging on their performance, and their pulse rates aren't usually reported in the newspaper for everyone to judge.

After his historic spaceflight, Shepard admitted to a few butterflies before liftoff. But when the launch managers—understandably cautious about gambling with someone's life—called yet another hold in the countdown with less than three minutes to go, Shepard turned angry, and gave them tacit permission to take the risk they all knew they had to take. "I'm cooler than you are," he barked into his mike. "Why don't you fix your little problem and light this candle?"

In the years since, this cool image has often been overplayed, as if astronauts were incapable of any other emotion. Standing on the moon in 1971, gazing up at the small, blue Earth, Shepard cried like a baby. We, of course, were not told about that at the time.

But on May 5, 1961, cool was exactly what was needed. *Light this candle.* Sometimes the only way to begin is to begin. And Alan Shepard, better than anyone, understood that. This issue of *Air & Space/Smithsonian* is dedicated to his memory.

*—The Editors*

October/November 1998
Volume 13, Number 4

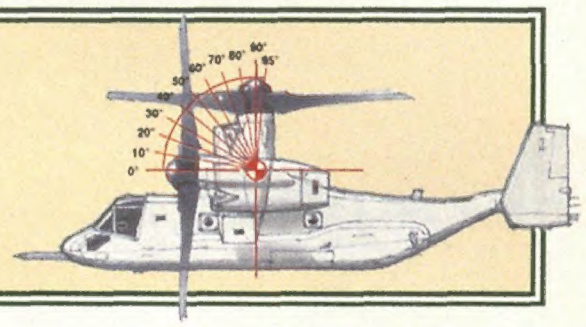
# AIR&SPACE

Smithsonian

CONTENTS

36







60



44




***Cover:***
*The Bell Boeing V-22 Osprey performs its characteristic rotor tilt. Illustration by Harry Whitver.*

***Departments***

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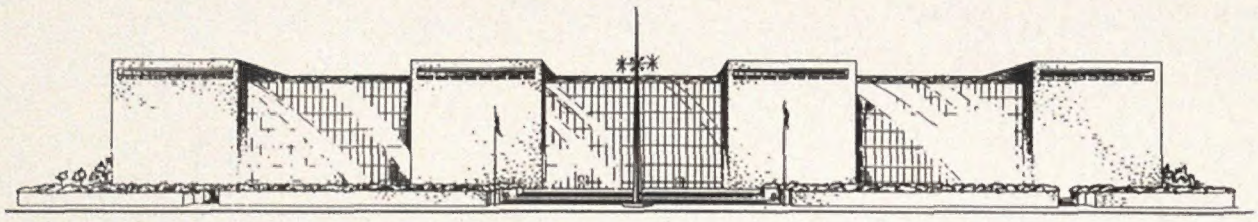

# Slippery Slope

Even if you don't own an airplane, your local airport is important to the quality of your life. And while most of us think of airports as big, robust, and permanent, they're actually quite vulnerable and can be lost forever if we don't work hard to protect them. I've seen it happen all too often, and the chain of events usually goes something like this:

A U.S. Army Air Force base with two crossing runways was built during World War II in a broad valley some distance from a city. The residents were proud when their town was chosen to be part of the war effort, and hundreds of cadets trained there on their way to combat and eventual victory. After the war the base was closed and deeded to the city.

In time, a general aviation manufacturer began to build airplanes there, and as the company prospered the plant expanded. Soon a fixed-base operator began to provide fuel and services, and hangars were built to shelter the increasing numbers of airplanes based there. The townspeople added a small terminal and restaurant, and everyone marveled at the growth out at the airfield.

Nobody paid much attention at first as houses were built nearby. Airport employees needed homes, and local investors and banks profited as farms were subdivided to meet the demand. Soon the two major roads to the airport were lined with gas stations and stores.

A second fixed-base operation and an aircraft ferry business arrived. Then a regional air carrier started scheduled service, so the city fathers built a bigger terminal and lobbied Congress to get Federal Aviation Administration support for more runways and a control tower.

Before long, the city limits expanded beyond the airport, and even more houses appeared. A national retail firm and a manufacturer of rubber goods moved their headquarters to the area, citing its location and the airport. Schools were built for the growing population, along with a much larger hospital. Soon some people began to express concern about the noise level near the field. Then, about the time new runways were completed, two general aviation airplanes had a midair collision and came down in the yards of two nearby houses. There were some letters to the local paper expressing concern, but people still complained more about the congested roads.

Soon after a major air carrier began service to the city, a former high official with the Department of Transportation, now representing a land developer, announced that houses could now be built closer to the airport because of stricter aircraft noise standards.

No one quite remembers just when the Citizens Against Aircraft Noise first met, but they got the ear of the publisher of one of the two newspapers. Other people complained to the city council about the dangers of having airplanes flying overhead. Still others began to talk about limiting landings and takeoffs. Anytime there was an aircraft accident anywhere in the country people began to ask, "Could it happen here?"

The companies that operated at the airport seemed to be more intent on business than addressing the rising opposition. The pilots and airplane owners were too busy and never got organized, and two vocal camps developed, with neither listening to the other. Now the city was divided over the very thing that had created growth and prosperity—the airport.

The city council met to address the issue but failed to affirm the importance of the airport to the community. As soon as it became clear that the politicians wouldn't support it, the airport began to die a slow, constrictive death. The rubber products company moved, but it was four years before anyone noticed that people were leaving too, and that stores were beginning to close on Main Street.

It's a story not of one city but of many, and I guarantee you all the events are true. Have you hugged your airport today?

*—Don Engen is the director of the National Air and Space Museum.*

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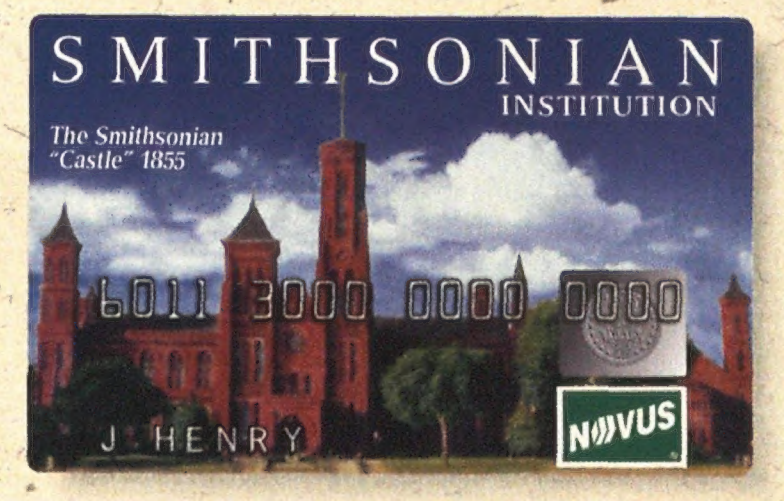


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# LETTERS

**Ode on an Aircraft Carrier**

Your photo-essay on aircraft carriers (Sightings, Aug./Sept. 1998) called to mind the following passage by Ernie Pyle, from his 1945 book *Last Chapter*:

"An aircraft carrier is a noble thing. It lacks almost everything that seems to denote nobility, yet deep nobility is there. A carrier has no poise. It has no grace. It is top heavy and lopsided. It has the lines of a well fed cow. Yet a carrier is a ferocious thing, and out of its heritage of action has grown its nobility. I believe that every navy in the world has as its number 1 priority the destruction of enemy carriers. That's a precarious honor, but a proud one."

—William Mensing
Santa Paula, California

**Two Boys, a Weasel, and a Long-Held Secret**

After years of silence, it is now time to tell the story of how two teenagers breached the top-secret Wild Weasel program ("Counterpunch," Aug./Sept. 1998).

My father was a flightline inspector for Republic Aviation. I grew up in the shadow of Republic and Grumman and made daily trips to the airfields to watch various aircraft undergo flight testing. As an inspector of F-105s, my dad would have to study the top-secret tech manuals. What he didn't know was that when his back was turned, I was also studying them, learning more about the workings of the -105 than I should have.

Fast forward to 1967. Republic F-105 production was shut down and the airport was now in civilian hands. A friend and I worked the nightshift as flightline personnel. That year, surface-to-air missiles were shooting down U.S. planes over North Vietnam. To convert F-105s for the Wild Weasel role, the Air Force began bringing the planes back to the place of their birth.

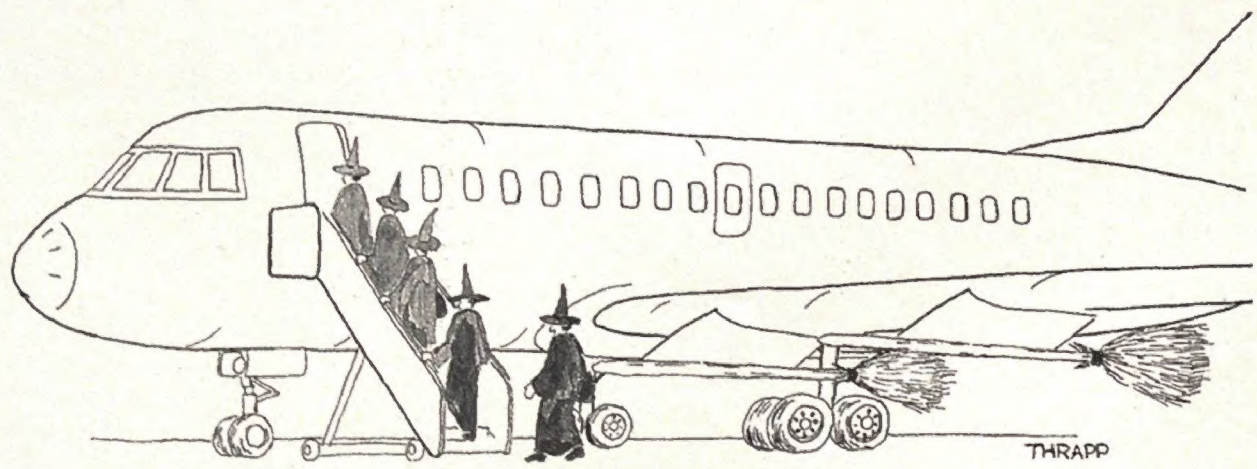
Security at the field was heightened. After the planes would land, they were surrounded by security vans and personnel, who would confiscate any cameras in the area. The birds would quickly taxi into Hangar 3, the windows of which had been blackened. Something mysterious was going on inside. My friend and I had to find out what.

Around midnight, just before shift change, we found a way to get into the hangar. We did not care about the miles of wire running around the -105s or the strange pieces of electronics all around. We just wanted to sit in the cockpits and be awed by these wonderful aircraft.

We repeated our game many nights. One night a guard came in to inspect the hangar and almost caught us. Little did he know that we were huddled in the cockpits of two nearby aircraft.

We both agreed that we would never reveal our secret, but now I've got to set the record straight.

—Judge John P. Wulle
Vancouver, Washington



### Mir-aculous

"Aiming for Arkalyk" (Aug./Sept. 1998) refers to the salamanders used in a Mir experiment as reptiles. I thought salamanders were amphibians. Were these specimens transformed in space? That would be a true scientific revelation, and reason enough to keep Mir going.

—Dan Harris
Chicago, Illinois

### Lifted to a New Life

One extremely important aspect of the Berlin Airlift not mentioned in "Heroes Welcome" (June/July 1998) was that the operation allowed thousands of East Germans to escape Communist oppression many years before the collapse of the Soviet East German government and the destruction of the Berlin Wall.

At the end of the war, the woman I would marry, Frieda, was trapped with her mother and three younger brothers and sisters on the east bank of the Elbe River; from 1945 to 1948 they lived under Russian domination. They wanted very much to reunite with Frieda's father, who had made a desperate escape to the West to get medicine he could not get in East Germany.

Before Berlin was divided by the Wall, East Germans were permitted to visit West Berlin. When the airlift began, Frieda and her family obtained passes to visit an aunt there. Once they arrived, they made daily trips to the Templehof airport in hopes of getting on an airlift plane's return flight to the West. But every plane was filled with other escapees. Finally, one family on the long waiting list failed to appear, and suddenly there was room for Frieda's family.

With nothing but their purses and a few belongings, they quickly boarded a coal plane for a flight to freedom.

—Bill Schulke
Eugene, Oregon

### Stratobuddies Wanted

As a young weapons technician on temporary duty at Brize Norton, United Kingdom, in the late 1950s, I witnessed an extraordinary demonstration of the B-47's flying ability ("Stratovets," Soundings, Aug./Sept. 1998). A Hawker Hunter, at the time a Royal Air Force first-line fighter, and a B-47 from our wing were playing cat and mouse at high altitude. Each time the Hunter would get nearly lined up on the B-47's tail, the B-47 would simply turn inside and the Hunter would overshoot and have to try again. It was astounding to see that big bomber make the much-smaller Hunter look so inept.

With the exception of my pal Bill in Pittsburgh, I have not met any other B-47 warriors whom I can swap stories with. How can I get in touch with the Stratojet association?

—George V. Adams
Christiansted, U.S. Virgin Islands

*Editors' reply: Contact Col. Sigmund Alexander, B-47 Stratojet Association, 12110 Los Cerdos Dr., San Antonio, TX 78233.*

*(Incidentally, the B-47 was not the United States' first turbojet bomber. The North American B-45 was, having entered service in November 1948, two years before the B-47. The error, which we regret, was introduced during the editing process.)*

### How I Changed the B-52 Forever

Bill Reich's letter in the last issue reminded me of times long gone. I was the designer who conceived and developed that crosswind landing gear on the B-52. You won't find my name on any of the drawings because the development work was done on a modified B-47. But I was responsible for the concept of steering the rear gear as well as the front to a nominal alignment with the runway, the concept of using the flux-gate compass signal modified by the angle of rear gear displacement as the indication of landing gear alignment with the runway (just keep the needle straight up), and the design of the B-47 modifications for tests of the concept.

I also modified Boeing's Link Trainer to provide a simulation of the steering control for the flight test engineers to try out. Tex Johnson was the first, and he pronounced the method "a cinch," even during a rough-air final approach.

Now for the odd part: I myself have never been close up to a flyable B-52, much less seen how the B-52A designers incorporated the system in the cockpit. I gave them my drawings and provided consultation during the design, then went on to other tasks. This has always nagged at me, and I hope one day I can climb into one of the B-52s at the Davis-Monthan base and see the result of my efforts. It was one of my first big design jobs at Boeing, and was quite a feather in the cap for a young engineer less than five years out of college.

—Robert W. Condon
Poulsbo, Washington

### Air & Space at the Movies: Two Thumbs Down

I enjoy your magazine and look forward to each issue. What I do not enjoy, and have become extremely confused about, is the appearance of such articles as "The Making of *Air Force One*" (Aug./Sept. 1997) and "The Wizards of What If" (Aug./Sept. 1998). From a scientific and technical point of view, the movies these stories describe insult anyone's intelligence. From a story/plot perspective, they are brain dead. Why did *Air & Space* promote them?

Both articles highlighted the experts who contributed their wisdom and experience to the films in question. Yet the filmmakers still give us such scenarios as multiple machine gun battles aboard a 747 with no serious harm being done to the aircraft, the U.S. government covering up the existence of an asteroid that would be almost as bright as the moon, and winged spacecraft banking and swooping in the vacuum of space.

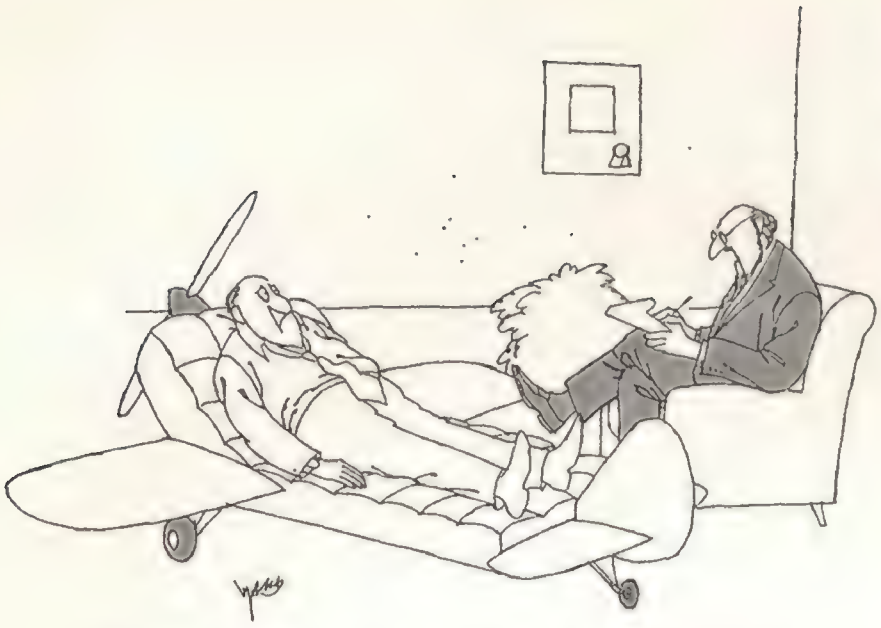
*Air & Space* can better serve the readers by highlighting the many flaws in movies like these, or better yet, by ignoring these fantastic abominations altogether and instead concentrating on real developments in aerospace.

—Pete Goldie
San Francisco, California


### UFO Mystery Solved!

Close to 20 readers tried their hands at identifying the aircraft in the photograph sent in by Joseph Haley Sr. (Letters, Aug./Sept. 1998). The consensus: The craft is a Hamilton Metalplane, though it's still unclear which model—perhaps an H-45 or H-47.

The boxy Metalplane was designed by John D. Ackerman (reader George Hurd recalled that at the University of Minnesota



*"Fortunately, fear of flying is one of my specialties."*

Institute of Technology, Ackerman "grudgingly allowed me to graduate at the bottom of the class"). Equipped with seven or eight seats, the craft were produced as both land planes and float planes. They debuted in April 1928, and the first production models, H-45s, were completed that September. According to an article by George Hardie Jr. for the Experimental Aircraft Association, customers included Universal Airlines, Wien Alaska Airways, Braniff, Isthmian Airways, the Ontario Provincial Air Service in Canada, and Northwest Airways (which called the Metalplanes "Cloudsters," according to reader James Mara, a retired Northwest captain).

The aircraft were manufactured by the Hamilton Metalplane Company (the plant was indeed located in Milwaukee, first on Park Street and later at the Milwaukee County Airport). The company was founded by Thomas Hamilton, later associated with Hamilton-Standard Propeller. We were fortunate to hear from Hamilton's son-in-law, James H. Scott II, who sent along an article he coauthored for the magazine *Air Classics*, based on interviews he conducted with Hamilton, who died in 1968.

In late 1928 the Metalplane company became a division of Boeing Airplane Co. Production of the Hamilton Metalplane ended in 1932. Today, only a few survive. One is at the Alaskan Aviation Heritage Museum in Anchorage, while another, which is flyable, is owned by the Lysdale Flying Service in South St. Paul, Minnesota.

## Corrections

*Aug./Sept. 1998* "The President's Plane Is Missing" (Oldies & Oddities): Jacqueline Kennedy Onassis' casket was flown to Washington, D.C., on a USAir Boeing 737-300, not on SAM 26000.

"Flying the Gusmobile": Gemini 11 flew in 1966, not 1965.

"Sport Jumps Don't Count" (Soundings): The photograph shows a civilian, not a Navy parachutist.

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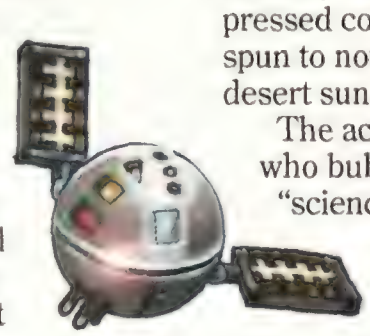
# Child's Play

Kelly Space and Technology has jumped on the cheap-reuseable-launch bandwagon with its "rocket on a rope" concept: First, tow an Astroliner manned rocketship to 25,000 feet with a Boeing 747 and disengage. Then get the Astroliner to fire its engines, climb to 400,000 feet, release the payload and its own booster, and glide back to Earth (see "Rockets for the Rest of Us," Feb./Mar. 1998). First launch is scheduled for around 2001.

Since dragging so large a thing so high is virtually unprecedented, the people backing the Kelly Eclipse Astroliner asked NASA's Dryden Flight Research Center in California to check out the procedure in the air. The Air Force provided a C-141A as the tow-er and a QF-106A drone as the tow-ee.

To get precise data from the half dozen flights, NASA fitted both aircraft with carrier-phase differential Global Positioning System units. However, to be sure the receivers were up to the job, the agency had to confirm their accuracy before the first flight.

True to the project's lowball budget philosophy, Dryden engineers mounted the GPS receivers and data transmitter units on a pair of their cars and proceeded to dance a motorized do-si-do along a desert highway to test the equipment. Post-road trip assessment: Good data.



Determining the units' ability to measure the tow cable's bungee effect had them stumped. Then Ed Haering had an inspired moment. Every day while driving his VW to work at Dryden, the engineer passed a playground in the Edwards Air Force Base military housing area. Prominent among the swings and jungle gyms was a push-power mini merry-go-round. Viewed from another perspective, the disk was an object of known dimensions that could be rotated at varying frequencies and could thus subject a GPS receiver to "periodic motions of fixed amplitude," precisely the measure that was needed. Moreover, the apparatus was in clear view of the GPS satellites.

Two engineering students from Texas A&M University mounted the device on the merry-go-round. One sat in the center with a receiver and battery. The less lucky Aggie got to hold the GPS antenna at the outer edge of the saucer's four-foot radius. Then the NASA pros gave the two a spin. Around and around and around they went, at speeds of up to one rev per second. Periodically the center student cheerily called out times while her G-pressed co-worker sweated buckets as he spun to nowhere under the broiling desert sun.

The activity attracted park regulars, who bubbled with questions about the "science experiment" and whose offers to ride along were gently refused.

After about 15 minutes the perspiring undergrad at the edge had nearly gone over it and was replaced by a NASA man with a stomach for Gs at very low altitude. The test took only 24 minutes, but to those intimately involved it seemed much longer. Still, the post-spin assessment made the trip worthwhile: Good data, again. The Astroliner Project went forward without a hitch.

Later, recounting that day in the playground, Haering hesitated when asked the facility's name. "I don't know the name," he admitted, "but I sure can tell you its lat/lon."

*—William Garvey*

WEB BRYANT

### *The Never-Go Navaho Returns*

Albert Martin lifts his chin, squints, and sniffles. He can't blame his allergies. The retired aeronautical engineer is gazing upon the one and only surviving specimen of the Navaho—that feckless winged missile that wouldn't fly right in the 1950s—and fighting back tears. "Looking at this right now, I got chill bumps all the way up and down my back," says Martin. Now 74 years old, he was just 31 when he launched the first Navaho on a 26-second flight that ended in a spectacular explosion. "It was the most exciting thing you could imagine. We didn't know it couldn't be done."

It was in July 1957 that the United States gave up trying to develop a supersonic pilotless bomber and went with ballistic missiles (see "Deliverance," Dec. 1996/Jan. 1997). The $300 million Navaho project itself may have been a bomb, but Brigadier General Randall Starbuck, commander of the 45th Space Wing at Cape Canaveral, Florida, says the "Never-Go Navaho" doesn't deserve to be called a failure. "Out of the ashes of its launch mishaps arose superior technology that would be the foundation of our missile and space programs for decades to come," Starbuck says.

The Navaho legacy includes gimballed rocket engines like those on the Saturn V and the space shuttle. Engines developed for the Navaho and modified over the years have launched more than half of all U.S. space missions. The missile's inertial guidance and navigation system was used in the Navy's first nuclear-powered submarine, the *Nautilus*, which traveled under the North Pole ice cap in 1958. Several of today's strategic missile systems use key Navaho guidance and propulsion technologies.

A freshly restored Navaho is going back on display at Cape Canaveral's Air Force Space and Missile Museum. After three decades on a pedestal by the sea, the North American Aviation G-26 missile and its companion booster needed $200,000 worth of restoration work that involved nearly complete disassembly, extensive corrosion control, the fabrication of missing parts, and new orange and white paint. To go with its sparkling new look, the Navaho is getting a sparkling new image as the "know how" missile that thrust U.S. technology into the Space Age.

The Navaho took off like a rocket and flew like the space shuttle. The booster carried the missile for 60 to 90 seconds, then dropped away to let the missile continue under its own power. The missile was supposed to cruise on ramjets at 80,000 feet and Mach 2.75, then land back at Cape Canaveral Skid Strip. None of the 11 test missiles launched between 1956 and 1958 ever got that far. All but one failed miserably, and the one success had to be destroyed when it received an errant ground command after a trouble-free, 43-minute, thousand-mile cruise to Puerto Rico. The tail numbers from the missile and booster used in that flight, 43098 and 013, are emblazoned on the refurbished Navaho, which the Air Force believes to be the last in existence. "Well, the last one above the surface of the ocean, that is," says Starbuck.

*—Beth Dickey*

CHRIS EADES

*Louis Blériot's flight last July to commemorate his grandfather's first crossing of the English Channel was considerably shorter than the 1909 original—by some 35 minutes. Blériot nose-dived one of the three remaining airworthy Blériot Type XIs into a pond two minutes after takeoff from Calais, France. The flight was made for a documentary being produced for the 90th anniversary of the historic flight. The vintage aircraft's owner, Jean Salis, who had twice reenacted the crossing, wept as his priceless craft headed unerringly for the water.*

*"I tried to turn left and right but it would not respond," Blériot said. "When I pushed the stick to the left it went right and it just kept going right. I can't explain it. I'm not hurt but the plane is not very well. Its right wing is broken but it could be repaired for another try."*

*—Stephen Bloomfield*

### *Cosmic Shrapnel*

For two hours before dawn this November 17 and next, observers in various locations around the globe will be treated to a spectacular atmospheric display when the annual Leonid meteor shower reaches its peak.

The Leonid shower—so named because its meteoroids appear to originate from the constellation Leo—occurs when Earth crosses the orbit of Comet Tempel-Tuttle. When the comet passes the sun, its ice layers begin to sublimate, or turn gaseous, freeing dust particles and debris the size of grains of sand. Over time, this detritus spreads out along the length of Tempel-Tuttle's orbit. But every 33 years or so, Earth crosses the comet's path soon after its closest solar approach and encounters a much larger zone of debris. The result is a dazzling meteor shower. The last one, on November 17, 1966, produced tens of thousands of meteoroids an hour.

While this year's fireworks aren't expected to be as stellar, they're noteworthy in a worrisome way: Earth's fleet of as many as 600 satellites are potentially vulnerable to bombardment. The energy carried by even the smallest Tempel-Tuttle particles could be lethal to satellites. It's a case of combined velocities and plasma physics, says Peter Brown of the University of Western Ontario. Earth is orbiting the sun at about 19 miles per second. The cometary debris is moving in the opposite direction at about 26 miles per second. At those speeds, even a grain of sand can pack a wallop equivalent to an artillery shell. Some aerospace experts believe at least one or two satellites will be disabled or destroyed by collisions with millimeter-size meteoroids.

Even if an impact doesn't kill or cripple a satellite, the sizable electric charge, generated when a colliding particle instantly vaporizes into conducting plasma, could destroy or severely damage a satellite's electronics. "The spacecraft that are up there are more numerous, more sophisticated, and more interdependent," Brown says. "Take out just one or two and you disrupt an entire [communications] system."

Nearly all satellites are at risk. The low Earth orbiters are moving along at about five miles per second. Their rapid orbital periods could send them rushing into the teeth of the shower perhaps twice during the peak two hours. Geostationary telecommunications satellites, moving at a more leisurely pace some 23,000 miles up,

will be in the path of the Leonids if they happen to be on the wrong side of Earth at the time. And several solar research satellites orbiting the sun, such as ACE and SOHO, will be exposed for the entire duration of the shower.

"There's a chance we'll go through the storm without any damage whatsoever," says David Lynch, research scientist with Aerospace Corporation of El Segundo, California. Precautions can be taken, he says: The Hubble Space Telescope will cap its mirrors and point away from the meteoroid flow, minimizing its cross section. No space shuttle missions are scheduled near the time of the shower. Some satellites can change the angle of their solar panels temporarily or power down some onboard electronics.

While there were no satellite losses during the 1966 peak, there now are roughly 10 times more satellites in orbit, and those satellites present up to 100 times more cross-sectional area as potential meteoroid targets.

For updates on the Leonid shower, see the NASA Web site at (note hyphen) http://www-space.arc.nasa.gov/~leonid.

*—Phil Berardelli*

### *Boat House*

Aviation enthusiasts in Oregon are feathering the nest for a very strange bird.

Voters in the town of McMinnville, about 40 miles southwest of Portland, recently blessed plans for a $20 million museum hangar to house the world's largest seaplane. The two-year construction project began last August and will run in parallel with a painstaking restoration of the HK-1 Flying Boat. Better known as Howard Hughes' Spruce Goose, the mammoth military transport will be the centerpiece of the Captain Michael King Smith Evergreen Aviation Educational Center at McMinnville Municipal Airport.

That used to be the Evergreen Air Ventures Museum. It took on the colossal moniker partly to satisfy a deal to purchase the colossal old airplane. "It was the only bid that offered to restore it as a learning center for the rest of its life," says Gary Thompson, the museum's executive director. The museum is named after its founder, who was killed in an automobile accident in 1995.

Michael Smith won the right to display the Spruce Goose in 1992 after the Walt Disney Company gave up trying to lure tourists to see it in Long Beach, California. Crew members from the wooden aircraft's sole flight—a 70-second, one-mile hop on November 2, 1947—were rounded up to help dismantle and shrink-wrap it in plastic for a 1,127-mile journey up the Pacific coast on an ocean barge (see "Special Delivery," Feb./Mar. 1993).

It remains in pieces, as shipped. Restoration of the flight deck and its maze of gauges was already under way last June, when the museum was receiving bids for reassembling the airplane. Thompson says the museum likely will again try to round up flight crew members to supervise. "It's extremely important," he says, "because this was a one-of-a-kind aircraft with some real unique problems."

There's virtually no metal in the HK-1. It's made of birch that was laminated with a phenol-formaldehyde epoxy that has crystallized with age. "For that reason, certain attach points are very critical, and it's going to require somebody that has knowledge of wood and the way it swells and bends with age—and really somebody that was there to see it come apart," says Thompson.

The hangar is an A-frame lodge with windowed front, a 125-foot apex, and more than 165,000 square feet of floor space to accommodate an aircraft with a 320-foot wingspan, 219-foot-long fuselage, and eight-story tail.

The museum has raised about half the needed construction funds through corporate donations, gifts, and souvenir sales. One of the more popular items is a swatch of the original linen that covered the airplane's control surfaces, with a certificate of authenticity, which goes for $26.50. Call 1-888-9SPRUCE or visit www.sprucegoose.org on the Web.

*—Beth Dickey*

EVERGREEN AVIATION EDUCATIONAL CENTER

ERIC LONG

*Two legends were reunited at the National Air and Space Museum last June for a taping of a "60 Minutes" story. Walter Cronkite, the CBS News anchor who covered 20 years of manned spaceflight, reminisced with John Glenn, who will return to space aboard the shuttle* Discovery *after 36 years. Cronkite will co-anchor the October 29 launch and November 7 landing for CNN.*

### *The Sweet Taste of Success*

Britain's future in space is being inched forward by amateurs in a converted Victorian industrial building in Byker, a suburb of Newcastle-upon-Tyne.

Space Quest Foundation is led by Derek Willis, a gangly 40-something physicist and engineer whose vision of Britain's future in space is based on the commercial market for sounding rockets and small scientific payloads. The key is a new type of fuel Willis has developed. In keeping with SQF's low-budget approach—Black & Decker power tools from home, handmade fiberglass rockets, borrowed launch sites—the design of the fuel is based, Willis says, on the bubbles of air in a chocolate bar called Aero.

Willis' Aerated Solid Propellant is a compound of standard lubricating oil combined with resin hardeners and suffused with oxygen bubbles. Once set, it resembles dried potter's clay, but it is inert and reasonably resilient to rough handling, and can be stored indefinitely.

What's crucial for even burning is the size and diffusion of the oxygen bubbles. Rocket fuel efficiency is measured by specific impulse, which relates the amount of thrust produced per pound of fuel to the length of time the fuel burns. Willis' propellant was initially rated at 60 but refined production methods using a higher-pressure infusion of oxygen have yielded a version with a specific impulse of 220 (the solid fuel boosters on the shuttle produce an SI of 268). Willis has impishly suggested that NASA could save

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$50 million a launch with his chocolate bar technology.

Willis hit upon the bubble idea last year while looking after his children as a house-husband between jobs. He manufactured the first batch of fuel using a commercial gas bottle and a homemade pipe-and-valve combination. Shortly after came funding from the Swiss-based confectionary giant Nestlé, makers of the Aero bar. All ASP-powered rockets are now dubbed Aero-Space.

Willis will be using the facilities of the Norwegian Space Agency in his next round of development, launching from the Arctic Circle base of Androja, a major launch site for European sounding rockets, and eventually graduating to a four-stage rocket designed to lift a five-pound package to 125 miles. Then SQF can start raising funds to build commercial rockets. The rocketeers say they can come in at 10 percent of the current payload costs charged by NASA and ESA.

Since the summer of 1997 the ASP manufacturing process has been developed, refined—and curtailed. The heavy hand of bureaucracy now lies across SQF, with further manufacturing and launches on hold until Willis convinces the local regulatory agency that he should be granted an explosives manufacturing license.

*—Stephen Bloomfield*

### *Japan's New Water Sport*

Yamaha Motor Company's *Aeroscepcy* took off smoothly from the platform, sank several feet in the hot summer air, then picked up speed and departed over the lake. With a bevy of motorboats in pursuit, the craft's transparent wings soon disappeared against the horizon.

The human-powered aircraft most Westerners remember is Paul MacCready's *Gossamer Albatross*, which crossed the English Channel in 1979 to claim the second Kremer Prize. But HPAs are thriving in Japan, where each July the International Birdman Rally is held at Lake Biwa, 30 miles north of Kyoto. Sponsored by Yomiuri-TV, the rally originated in 1977 as a distance gliding contest. Human-powered craft were added in 1985 and are now the main attraction, with $30,000 in prizes.

Aircraft take off from a 33-foot-high platform that extends 164 feet from Biwa's eastern shore. The shortest distance across the lake is nine miles, but headwinds usually force aircraft to veer north, doubling the mileage. Few craft surpass even half a mile, and I asked Kanazawa University's team captain, Yomoyuki Kondo, why they fly out to the middle of Japan's largest lake in the first place. He looked at me and shrugged. "Maybe we'll cross the lake someday?" Until then, powerboats tow wrecked craft to shore, where they are recycled for next year's rally.

The event sets Yomiuri-TV back more than $500,000 for powerboats, a helicopter, cameramen, divers, and a staff of 400-plus. While Yomiuri recoups costs when the event airs on national TV in September, teams depend on corporate sponsors. Aircraft can cost $20,000 and require 5,000 construction hours. About half the entrants are university students, who receive credit for their work. The rest, like Yamaha's *Aeroscepcy*, are sponsored by their employers.

Construction is simple: Wing ribs are cut from foam and reinforced with carbon or balsa. Carbon-tubing spars are the norm, reinforced by steel guy wires, and surfaces are covered in Mylar film. Fuselages are typically pod and boom. Wingspans average 90 feet, and most teams aim for an aircraft weight of under 90 pounds.

By noon, the last aircraft was making its way up the ramp. *Jinriki Herikoputa-kai* was the most beautiful aircraft in the running; its wing sported 230 ribs and an intricate trussed spar. But while ascending the ramp a wingtip caught on a guard rail and the delicate spar crumpled. After 10 minutes of furious activity it was ruled irreparable. The outer panel was trimmed off at the break and the opposite panel trimmed to match. Its builders intended *Herikoputa-kai* to fly, with or without wingtips.

Officials debated whether to allow the flight. For a while it looked like *Herikoputa-kai* might get a chance, but flying was deemed too dangerous. (No pilot has ever died in the Birdman rally, though there have been broken bones.) The team asked to launch its craft without a pilot, and officials assented. Water bottles were hurriedly taped to the frame to adjust the center of gravity, and with a final heave-ho *Herikoputa-kai* was shoved from the platform. Team members shouted "It's flying! It's flying!" as it sank into the lake. The last entrant of the 1998 human-powered aircraft contest carried no human at all.

Kenji Kitamura, production manager for Yomiuri-TV, pointed at the *Herikoputa-kai* team members and said: "This contest is a lot like life. A lot of hopes and dreams crash here." In one sense he was right: No one has ever crossed the lake, and by that standard all teams have failed. But after more than an hour aloft, Yamaha's *Aeroscepcy* had smashed the previous record of six miles with a flight of more than 14 miles—though it too failed to make land.

*—Eric Stewart*

ERIC STEWART (2)



**New Engine Certified**

Orenda received certification from the Federal Aviation Administration and Transport Canada for its 600-horsepower V-8 reciprocating aircraft engine last May ("Power Struggle," Dec. 1996/Jan. 1997). The company has commenced delivery of 140 of the liquid-cooled, turbocharged engines to Stevens Aviation in South Carolina for installation in Beech King Airs, and also has retrofit programs for the Rockwell Twin Commander and the de Havilland Beaver and Twin Otter.

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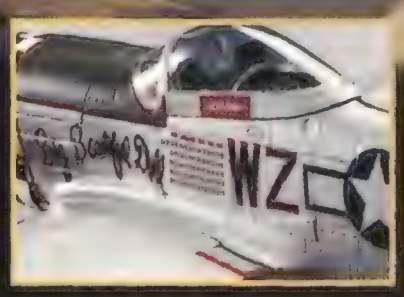

The "Big Beautiful Doll" was one of the most famous of all the Mustangs. Their pilots boasted 14 air-to-air kills, destroyed at least 20 German planes by strafing action and were the overall dominant force in the European Theater.

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### *How To Solo at 14*

When Wyman Fox answered the phone on June 15, 1996, he had little idea of the events he would set in motion. Fox, 60, is a retired Marine and a former postal worker from Martinez, Georgia, who started flying seven years ago. He is also an active leader in the Experimental Aircraft Association's Young Eagles program, which encourages EAA members to take youngsters for their first airplane ride. Usually Fox had to recruit youngsters to try the program. As he recalls, "In the four or five years I'd been doing it, I never had a kid who called *me*."

The voice on the line belonged to Jamail Larkins. A 12-year-old from Martinez, Larkins wanted to go flying. Fox didn't wait for the next scheduled flight. Two weeks later, he says, "I went by his house, picked him up, took him out to the airport, and we started flying around." After the flight, Larkins decided "I liked it so much I asked him if I could go along on all the Young Eagles rallies." Fox treated Larkins to his first lesson on his 13th birthday, and loaned him his own Cessna 172 to train in. At the Sun 'n' Fun

CHRIS THELEN/THE AUGUSTA CHRONICLE

fly-in in Lakeland, Florida, early the next year, Larkins worked the Young Eagles booth, encouraging other kids to try a first flight. At the fly-in, Larkins was invited to the annual EAA fly-in at Oshkosh, Wisconsin.

Larkins had some "friends from on the Internet" at American Airlines, and soon he had round-trip tickets to Oshkosh and was on his way. The previous December, Larkins had written to the FAA asking for a waiver of the rule requiring him to be 16 years old to solo. He says, "I'd flown with six different instructors and two designated flight examiners, and they all supported me." But the FAA turned the waiver down. Enter Lloyd Richards.

When Richards saw Larkins at Oshkosh, he recognized him immediately from the Sun 'n' Fun fly-in. "I'm in the booth and I look across and here's the same smiling face," Richards recalls. "I ambled over and said hello and we chatted about what he was doing, how he got up there on his own. After a few days we got to be pals." A friend of Richards told Larkins that he should come up to Canada, where he could solo at 14. "I guess Jamail decided I was his best friend at that point," Richards says. Months later, "My phone started to ring every Sunday night at 7:30 or 8. 'Hi, Mr. Richards, this is Jamail Larkins, how are you?' As we got in towards spring, we decided he should come to Canada and go solo."

With help from companies like aviation insurer Avemco, Larkins flew to Canada and stayed at Richards' house while they went through the process of obtaining a medical certificate. Transport ministry staffer Debbie Fyfe helped expedite the paperwork, and within a week of faxing the results of his eye exam, Larkins had a Canadian medical certificate. He was now a student pilot.

July 14, 1998, dawned clear and calm at the airport in Timmins, Ontario. After three circuits around the pattern, Larkins' instructor asked him to taxi clear of the runway. He called the flight service station to advise them his student was about to solo, and then, in that moment no pilot ever forgets, he jumped out of the Cessna 172 and told Larkins to be sure to lock the door.

"I couldn't actually believe what I was about to do," Larkins says today. "I really wasn't nervous until I got back down." He was also wet: In a time-honored tradition, the flightline crew doused him with two buckets of water.

Last July at Oshkosh, Larkins was introduced to the aviation press corps during a Cessna-sponsored news conference. With remarkable poise, he told the roomful of crusty reporters about his pursuit of a solo flight. Yes, he said, he wanted to pursue a career involving aviation ("He's got it all pretty well mapped out," says Wyman Fox).

"What particular part of aviation?" someone asked.

"Management," said Larkins.

*—George C. Larson*



**Incoming**

NASA is setting up a Near-Earth Object Program Office at the Jet Propulsion Laboratory in Pasadena, California, to find and track asteroids and comets that could threaten the planet ("This Target Earth," Oct./Nov. 1991). The goal of the new program is to detect 90 percent of some 2,000 near-Earth objects larger than half a mile in diameter by the year 2010.

### *Less Is More*

"It's pretty exciting, using a telescope smaller than most amateur astronomers own to date the universe," says Jaymie Matthews of the University of British Columbia and the principal investigator of MOST, the Canadian Space Agency's latest science project.

The suitcase-size spacecraft houses a telescope whose main mirror is only six inches across. MOST (Microvariability and Oscillations of Stars), which will be launched in 2001, is so diminutive it could fit in one of the Hubble Space Telescope's communication dishes, but it may answer a question Hubble hasn't: How old is the universe?

The sun's interior heat causes its gases to behave like boiling water in a kettle. The gases' energy is transferred to the sun's surface, making it vibrate at several hundred feet per second. As a star ages, turning hydrogen into helium, the ratio of the two gases changes and the sound waves take a different path, which shows up as a different vibration pattern on the star's surface. By studying this pattern, astronomers can discern the ratio of hydrogen to helium and therefore the star's age. Helioseismology, the study of these solar vibrations, establishes the sun's internal structure and age based on this constant surface ringing.

Our sun is the only one astronomers have seen ringing. But there's no reason it should be unique. Says Tim Brown of Boulder's High Altitude Observatory, "The holy grail of stellar seismology has...been to measure pulsations on other stars that are similar to the sun." MOST is an attempt to study the surface vibrations on other stars. As no child can be older than its mother, no star can be older than the universe. If MOST determines the age of stars older than our sun, a "no younger than" date is stamped on the cosmos.

Two problems crop up in extending helioseismology to other stars. The atmospheric turbulence that makes the

stars twinkle renders the vibrations astronomers seek invisible from Earth. But put even an amateur-size telescope into space and detecting them is a snap.

Matthews estimates he needs a year of uninterrupted "listening" to the six or so stars on his target list to hear all the ringing. MOST, he says, "is a challenge [because] we're hoping to detect variations in [brightness] at the micro magnitude level, a few parts per million." It's a big job for a spacecraft so small that Matthews has nicknamed it the Humble Space Telescope.

*—Barry Shanko*

ERIC LONG

*Launched in 1996 and promoted as the beer that fell to Earth, Apollo is being marketed with references to the thrill of the Apollo missions and space exploration.*

*The American oak that gives California Chardonnays their distinctive taste is being used to age Apollo beer. Microbrewed in Saint Paul, Minnesota, Apollo is sold as both an ale and a lager. Targeting young upscale customers, a six-pack costs $8.*

*"It's actually quite good," says Walter Schirra, who flew on Mercury, Gemini, and Apollo. "We have no claim to the name Apollo. I'm proud of what we did, and if this beer has fun with it, that's great."*

*What's NASA's take? "I'm not even familiar with this beer, but regardless, we wouldn't have much of a reaction one way or the other," says agency spokesman Brian Welch.*

*The consensus of the taste testing team at* Air & Space/Smithsonian*: The cobalt-blue bottle is the biggest attraction.*

*—Karen A. Sager*

# The Luftwaffe's Best Piston Engine Fighter

ERIC LONG

*Rich Horigan repairs the tail of a Focke Wulf Ta 152 H-1, a World War II Luftwaffe fighter. Ta 152s were variants of the Focke Wulf Fw 190, which was modified for high-altitude flight (below).*

Toward the end of 1944, a German pilot climbed into a sleek, low-wing fighter parked at the Langenhagen airfield in northern Germany. Powered by a 12-cylinder, liquid-cooled inline engine and adorned with large black swastikas on the tail fin, the airplane rolled quickly down the runway and climbed into the air. Seconds later, the pilot received a warning from the air traffic control tower: Four Allied aircraft were approaching. The attacking airplanes were P-51 Mustangs, the United States' premier World War II fighter.

The German pilot, however, needn't have worried. He simply pushed the throttle forward to the emergency setting, automatically activating a methanol-water injection system designed to increase the power output of the Junkers Jumo 213 piston engine at low altitudes. His airplane burst into a sprint, and the Allied pilots soon gave up the chase.

NASM

The aircraft that had eluded the P-51s was a Focke Wulf Ta 152 H-1. Designed and manufactured late in the war as a high-altitude interceptor-attacker of Allied bombers, the Ta 152 was a variant of the Focke Wulf Fw 190, which was flown by hundreds of Luftwaffe pilots as both a fighter and a ground attack airplane. The Ta 152, however, was superior to the Fw 190: It could fly higher and faster, and it was more maneuverable.

Not surprisingly, Luftwaffe pilots liked it. "I'd never had such a fast airplane under my behind in my life," one recounted to a U.S. historian. And Harold E. Watson, who retired as a U.S. Air Force major general, also praised the Ta 152: "It was beautiful to fly. A first-class airplane." After Germany surrendered in May 1945, Watson headed a group of U.S. pilots known as Watson's Whizzers, which was given the job of rounding up German aircraft for test flying in the United States. The Ta 152 was on the Whizzers' list, but the fighters weren't plentiful. Of 67 manufactured, some had been lost in combat and others destroyed by German pilots who didn't want them to fall into Allied hands. But the Whizzers got dibs on a Ta 152 that had been picked up by the British in Tirstrup, Denmark. Along with dozens of other German aircraft, it was shipped to the United States aboard a British aircraft carrier.

That Ta 152 now belongs to the National Air and Space Museum. The only surviving example in the world, the fighter is currently undergoing much-needed repairs to its empennage at the Museum's Paul E. Garber Preservation, Restoration and Storage Facility in Suitland, Maryland. At some point after the Ta 152 arrived in the United States (probably when it was undergoing flight testing at Freeman Field in Indiana), its new owners added an aluminum reinforcement on the mounting for the horizontal stabilizer. And to cover the holes that had been cut through the original plywood skin, U.S. airmen spliced

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COLUMBIA HOUSE

in new panels of plywood.

Senior restoration specialist Rich Horigan is just finishing up a five-month project to return the Ta 152's tail structure to its original configuration. "I had to first go in and figure out what was originally German-built on the plane and what was later put in by the Americans," says Horigan. "I've used archive microfilm and drawings." He began by removing the plywood panels, which had rotted, and he also took out the aluminum mounting for the horizontal stabilizer. Then he covered the holes in the empennage with pieces of plywood carefully matched to the thickness of the originals.

Horigan will finish off his work on the tail by painting over a motley assortment of markings. On both sides of the tail fin are traces of the large black swastikas applied by the Germans, and on top of them is the smeared red, white, and blue paint of a "finflash"—a rectangular insignia applied by the British after they captured the aircraft. Finally, there are the remains of two small black swastikas, which U.S. airmen painted at the top of each side of the tail fin for display purposes. Since Horigan does not want to sand off these historic markings, he is smoothing the surfaces of the tail fin just enough so that he can apply fresh coats of paint, over which he'll paint swastikas duplicating the originals.

In addition to his repairs to the tail, Horigan is working on obtaining and installing flight instruments missing from the cockpit display panel: the artificial horizon, altimeter, cockpit pressurization gauge, and oxygen gauge.

Though the Ta 152 was designed to shoot down Boeing B-29 bombers at high altitudes, Luftwaffe pilots experienced numerous glitches in the cockpit pressurization equipment, so most of the time they had to fly at those altitudes unpressurized. In any case, B-29s never showed up. The Ta 152s, particularly those assigned to Fighter Wing 301 (which is where the Museum's airplane came from), provided aerial cover for Messerschmitt Me 262 bases near Berlin. The Me 262, the world's first operational jet-powered warplane, was one of the crown jewels in Germany's cache of wonder weapons. The twin-engine Me 262 could reach 540 mph, far faster than any Allied piston engine fighters. But in the last six months of the war in Europe, Allied forces had air superiority over much of Germany, and Allied aircraft, such as P-51s and P-47 Thunderbolts, had been arriving by the thousands.

Using a tactic known as rat-catching, Allied fighters, usually P-51s, would attempt to shoot down Me 262s when they were most vulnerable: either just after takeoff, before they had built up much speed, or as the jets slowed down to enter the landing pattern. "The U.S. Allies knew where the German jet bases were, so they would have patrols flying around in circles, loitering, waiting to spot German jets landing or taking off," says Tom Dietz, one of two curators assigned to the Museum's Ta 152. "And [the P-51s] would try to build up speed, dive in, and attack."

It was up to Fighter Wing 301's Fw 190s and Ta 152s to shoot down the marauding Allied fighters. Each Ta 152 was equipped with a 30-mm cannon that fired through the propeller spinner and two 20-mm cannon, one in each wing root. But even with this armament, plus the ability to outrun and outmaneuver the P-51, the Ta 152 was badly outnumbered. "By the time the Ta 152 entered production, the German aircraft industry was facing severe problems: lack of raw materials, constant Allied bombing, and labor shortages," says Dietz. "They were also facing losses of skilled pilots after more than five years of war."

Today Rich Horigan works diligently to restore the once-hot airplane. "It is rewarding to work on this aircraft from the viewpoint that things you do now will stay around for centuries, so people like your children and grandchildren can see this plane and know that you did it," he says. When he finishes the repairs, the Ta 152 will go back on display in Building 20, and after the turn of the century, it will be moved to the Dulles Center, where it will undergo a complete restoration involving corrosion control, tire preservation, and the painting of the fuselage. In the meantime, visitors to the Garber facility can be reminded of the last chaotic days of the war, when, for a fleeting moment, Ta 152s filled the sky with promise.

*—Karen A. Sager*

### *Museum Calendar*

*Except where noted, no tickets or reservations are required. To find out more, call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.*

**October 15** G.E. Aviation Lecture: Chuck Yeager returns for his annual presentation. Free tickets are available at the Langley Theater box office. Langley Theater, 7:30 p.m.

**October 17** "And a Star to Steer Her By," a new planetarium show, opens to the public. The 30-minute feature describes how navigators have steered their courses over the years. Einstein Planetarium, seven shows daily.

**November 7** National Air and Space Society Lecture. "VF-32 Swordsmen in Combat at the Chosin Reservoir," an evening with Captain Thomas J. Hudner Jr., U.S. Navy (ret.). Hudner will reflect on his missions as a carrier pilot during the Korean War. To obtain free tickets, call (202) 357-3762; e-mail nass@sivm.si.edu.



ERIC LONG

*Last July, "Earth Today: A Digital View of Our Dynamic Planet" opened in gallery 113. Vice President Al Gore, a longtime proponent of environmental preservation, attended the opening reception and praised the exhibit, which synthesizes and displays in near-real time images and data gathered from Earth-orbiting satellites. Housed in a 16-seat theater with a large screen, "Earth Today" continuously updates visitors on global conditions such as cloud cover, water vapor, earthquakes, and the biosphere.*

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# The Broad Side of a Barnes Door

A fistful of wig hair beats on the outside of my leather helmet. One end of a white silk scarf flaps behind me. I turn to see if it blocks Charlie Hillard's view. He looks past me at the ground ahead. We are level with the treetops.

A helicopter follows on our left. The cameraman's legs hang out the door, and his face is one big lens. Through my earphones Charlie says, "Wave your hands over your head and grin like you're having fun."

I am having fun.

I'm a professional stunt pilot, but five years ago I left the drama and daring of barrel rolls and biplanes to raise two children. Now they are five and eight years old, and this is my first flight back in the movie flying business. My hands wave in the air: Yes!

In the made-for-TV movie *Pancho Barnes*, the legendary flier is on her first flight in 1925 in a dilapidated Tiger Moth. The reality is that this is Denton, Texas, in 1988, and although the Tiger Moth looks worn, the streaks and rust are painted on.

Later, I kick the Tiger Moth into a spin. The cameraman in back is a big man with a big camera, and some maneuvers—like a spin—are best done with little people in the back seat. I haven't spun an airplane in five years, but I don't mention this. Trees and meadows swirl in the windscreen, rushing toward us. When we pull out he says, "Do that again, only shaking your hands over your head this time."

A spin is a two-hand, two-foot maneuver. I kick it in again. My left leg extends all the way to the rudder stop, my right leg bends so my knee can hold the stick back against my thigh, freeing my hands so I can flail them above my head. The effect is half-spin, half-spiral. All this for one moment of film.

Nothing is too much trouble for a good shot. It's like the hangar they are building on the runway. A crew hammers, saws, and nails boards as if the structure will shelter an army of airplanes in a hurricane, yet its sole purpose is a single scene. By flying through it in a Stampe biplane, Barnes will stand up to Howard Hughes, wow the Hollywood stunt pilots, and dazzle her love interest.

COURTESY DEBBIE GARY CALLIER (2)

*"Charlie & Deb—we took turns wearing the wig," reads the author's inscription on the back of this snapshot. Charlie Hillard and Debbie Gary Callier alternated in the role of Pancho Barnes, Pilot.*

Charlie Hillard will be the pilot, and for him it's a one-shot deal. He has never done a stunt like it before, but neither has any of us, though each pilot thinks about it every day. We stop and take sightings, mentally pace the door frame, subtract the length and height of our wings: a clearance of 10 feet on either side, an aircraft's height above. Then we gauge the feeling in our stomachs. You have to get the feeling. It is not something you can will; it is something you wait for. I don't have the feeling—not yet.

In a week the hangar will be fleshed out with windows, walls, and rooftop. Today it looks like a bridge: A-frame roof trusses suspended over telephone pole-size pilings. Men with hammers and two-by-fours wave as I taxi past.

We have airplanes assigned to us, and I will fly a silver Ryan STA monoplane and a tomato-red Taperwing Waco biplane. The owners stand around while we inspect their babies. Some are earnest, chattering stage moms. "With a rotary engine, be sure to pull the prop through by hand every morning," one says. "Don't forget, the Stampe is British, so the prop turns the other way," another advises. "Be sure to wheel-land the Ryan." "Watch the Fokker in turns." We listen and nod, collecting our own impressions as we touch the wings and sit in the cockpits.

Troy Stimson has a collection of airplanes that fly in movies. He is flying some of them himself and he is anything but nervous about us flying them. "Want to fly the Parrakeet?" he asks me one evening as we put the others away.

"Do I ever!"

Each airplane is like a dance partner: The little ones prance, the big ones lumber. We have our favorites, but we never tire of new ones. Except for the Tiger Moth, these are all new to me, and I want them all on my dance card.

I don't even look for a helmet—I just hop in and fly. The wind snarls and knots my hair, but I loop, roll, dive, and zoom. The Rose Parrakeet biplane is an angel.

The next day I am Amelia Earhart in the Ryan. We are racing and everything is scripted: I win some, I lose some. But I'm caught by the mood of competition. I

want to win all the races.

When we film the dogfight scene, I am Pancho, and I get her wig and the Taperwing Waco. Charlie gets Frank Clarke's mustache and the Stampe. Gene Soucy is Leo Nomis in the Fokker triplane.

In the story, Clarke and Nomis are Hollywood stunt pilots and Pancho will ruin their scene. Director Stan Neufeld tells me what he wants: "They'll be circling. When they get opposite the helicopter, you dive between them."

I hear the words, conjure up a picture, but I don't have the feeling. Gene and Charlie circle while I climb. The helicopter hovers with director and cameraman on board. Meanwhile, my brain chatters. "If I'm here and they're there and they're going to be here when I get there, then..." I draw lines and circles in my head and think of what I know about formation rejoins, collision courses, and near-misses. It is like skeet shooting: Lead the bird.

From up high I roll into my dive, half on my back to try to keep them in sight, but I miscalculate. Both airplanes zip past and we are nowhere near a good shot. I try again but nervousness throws me off. I botch it three times, then Charlie says, "Go back and land."

I shut down the Waco and give Charlie the wig. He climbs in the Waco wearing both Pancho's wig and Frank Clarke's mustache. "You get in the Stampe," he says.

The Stampe was off-limits—that is what Charlie will fly through the hangar. But now I'm in it, and it's light and quick. I rack it into a tight turn and race off after him.

He climbs and I catch up with Gene's Fokker. I jockey the throttle and vary the back pressure. The Stampe does ballet, where the Waco did a square dance. Now I chase the Fokker and the Fokker chases me. Charlie climbs and dives and misses, just like I did. Gene and I break out of our dogfight and tuck into formation on Charlie's wings. Now we are Clarke and Nomis jumping Pancho, forcing her to land.

For two full weeks we are stunt pilots playing stunt pilots. We stage races and crashes, bad landings and winning flights. Then the stars arrive. Valerie Bertinelli walks into the hangar; she has long, curly dark hair and is wearing jeans, a white T-shirt, and no makeup. At first, no one recognizes her. "Can you show me around the airplane?" she asks.

We all spring to life.

"What do pilots talk about?"

"Wings, weather, wind..."

"Sex," someone says.

She laughs. "And what kinds of things do they do to their airplanes?"

Actor Sam Robards already knows. He flew his father-in-law's Aero Commander to the movie set. We show the actors how to climb onto the wings and into the cockpits.

Days later they are all pilots. Valerie is Pancho with the boys, flirtation and machismo. They talk crosswinds and crescent wrenches. Actor Geoffrey Lewis leans on the Tiger Moth, wiping grease off his hands, like he was born at an airport. Flawlessly, they jump in and out of character, the way we jump in and out of airplanes. Now we are stunt pilots doubling for actors who are playing stunt pilots doubling for actors.

Actress Nance Williamson slings her flying boots into the Ryan, where I hunker down, feet on the brakes, keeping the engine running. She is Amelia Earhart and Pancho has just wrecked the Travel Air Mystery Ship taking off in front of her.

Pancho hops off the Waco's wing, wearing her helmet and goggles. She has ruined the dogfight and the boys have forced her to land. Frank Clarke strides up and punches her in the chest. "Listen, sport, you just landed in a whole bunch of trouble," he says. She rips off her helmet. He is wide-eyed with put-on anger. They will do it over and over, as they will every scene, except for one: the hangar fly-through.

Today is the day. It is early morning and a big crowd has gathered. Even my children are here—Laura gets Valerie's autograph, while Dave sits in the Fokker making machine gun sounds.

A crew has taken down the three stout poles they planted in front of the hangar doorway. The poles appeared the day after I got the feeling. In my mind, the hangar was suddenly a tunnel and I was shooting through it. There must have been a long line of us who'd gotten the feeling, because the next morning three tall black poles stood guard at the door.

Charlie suits up: Pancho's wig, helmet, scarf, and leather jacket, plus his Bermuda shorts. It is another hot Texas morning, not the best day. The breeze is a crosswind, which does not help.

He climbs in and the rest of us chatter. "Wish it was you?" "Yeah, should have done it when nobody was looking," we say, but we don't mean it. It is Charlie's moment.

He takes off, makes some low passes, then turns and drops down over the trees, then lower—three feet off the ground. He's got the feeling. You can see it. His mind is through the hangar and he is level as a carpenter's line. The big cameras roll; the little ones click. Not a word from the crowd. Few people breathe. Airplane is still coming, prop chewing the air. Almost there. Through the first door. Prop echoes against the corrugated walls. Out the second door and up over the trees.

We jump and shout, clap and cheer like people in a movie who watch a friend do what can't be done, and we are proud for him.

*—Debbie Gary Callier*

*SFX unmasked: Valerie Bertinelli takes control of the uncontrollable for the cameras.*

# MOONSTRUCK

According to a 1995 *Time*/CNN poll, six percent of Americans don't believe that astronauts ever landed on the moon. The government faked the landings, they believe, at a top-secret movie set using state-of-the-art special effects.

The way the conspiracy buffs see it, technical problems like the 1967 capsule fire that killed three astronauts convinced NASA heads they could not meet Kennedy's end-of-the-decade deadline for landing men on the moon. Or scientists discovered that the Van Allen belts would zap astronauts with a lethal dose of radiation, a theory offered by James M. Collier, a freelance journalist who has produced a video titled *Was It Only A Paper Moon?* Whatever the cause, the doubters claim, government officials refused to accept defeat. Rather than give up the prestige of human spaceflight, they concocted a huge conspiracy.

The tale the doubters weave sounds like an "X-Files" episode. Many of their charges can be traced to *We Never Went to the Moon*, an obscure book by Bill Kaysing published four years after the last lunar landing in 1972. Although Kaysing admits the book was "pure speculation," his charges continue to guide modern disbelief.

Kaysing writes that the moon hoax project took place at a super-secret military base in the Nevada desert, 70 miles north of Las Vegas. Just up the road is the infamous Area 51, where government agents allegedly stored the remains of a flying saucer that crashed at Roswell, New Mexico. (Aliens occasionally pop up in the moon hoax story, but serious hoaxers do not traffic in them.)

According to Kaysing, proximity to Las Vegas allowed government agents to recruit Mafia families to enforce a code of silence. One example: An aerospace employee who worked on an Apollo module died suddenly after telling a Congressional investigating committee that the United States would never reach the moon. (Quality control inspector Thomas Baron did in fact die in a railroad crossing accident after criticizing employee behavior at North American Rockwell before Congress.)


DAVID CLARK

Apollo astronauts joined the conspiracy to help win the cold war, the skeptics maintain. Saturn Vs thundered off from Florida's Kennedy Space Center, but the astronauts were not on board, having disappeared from the capsule just before launch. The empty capsule fell into the ocean as the astronauts were flown to the Nevada site, arriving in time for live TV broadcasts from what appeared to be space. Between broadcasts, they dined on banquets catered by the Dunes Hotel and enjoyed the company of Las Vegas showgirls recruited to work at the secret facility. Conspiracy buffs maintain that at least one astronaut cracked under the pressure of maintaining the code of silence.

Reentry? No problem. The astronauts simply climbed into a new capsule, which was dropped into the Pacific from a high-flying cargo aircraft.

The hoax advocates say they have proof. As a rule, movie producers cannot create entirely error-free special effects. Space dweebs, for example, know that the launch sequence in *Apollo 13* was produced in a studio because at liftoff the swing arms on the launch tower retract one after the other, instead of simultaneously, as in a real launch.

Some skeptics point to strange shadows and lighting effects in photos that astronauts took on the moon, suggesting the presence of stage lights or atmospheric diffusion. Others note weird dust plumes kicked up by the lunar rover that seem inconsistent with an airless world, or question the fact that shots from the lunar lander show strange light rays as the lander touches down.

The hoax theorists say the most intriguing piece of evidence appears in a NASA-produced film on Apollo 16 that was later released as a video. The footage shows Apollo 16 astronauts picking up lunar samples on a ridge half a mile west of the landing site. The next day they travel two-plus miles south to a new site, Stone Mountain, producing more film. A close inspection of the two locales reveals that they are the same. Skeptics offer this as proof that the two forays took place on a single movie set. The faithful see it as a case of sloppy editing by a contractor.

Where will it end? One day after NASA released the first Pathfinder pictures from Mars, reports appeared on the Internet offering proof that the lander photos were a "brilliantly conceived hoax" produced at Steven Spielberg's DreamWorks Studio. To some, the thrill of space can't hold a candle to the thrill of conspiracy.

*—Howard E. McCurdy*

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# Extreme Machine

***The U.S. Marine Corps' sword gets a brand-new edge.***

by George C. Larson


ERIK HILDEBRANDT

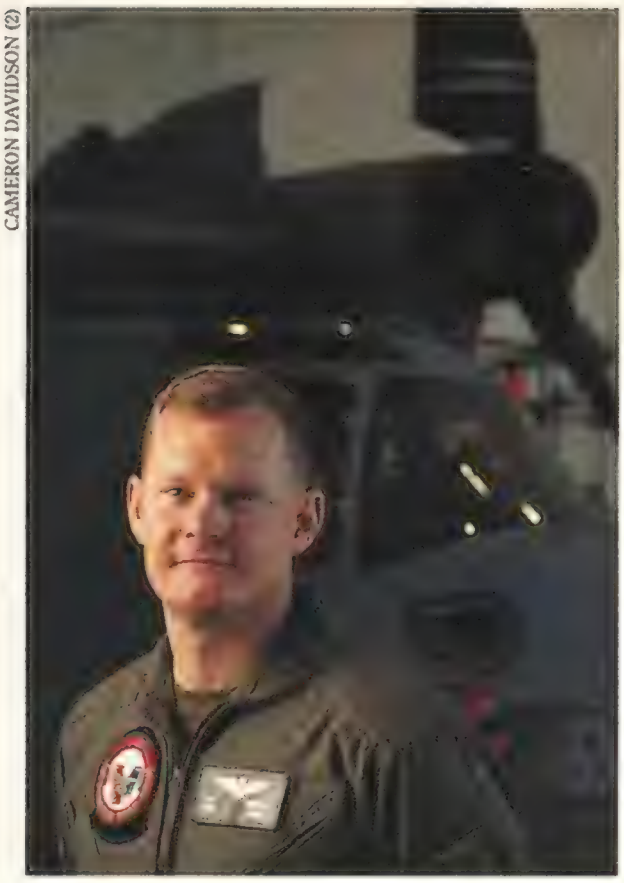
Only two hours or so after getting under way, the operation began to unravel. On the evening of April 24, 1980, eight U.S. Marine Corps Sikorsky RH-53D Sea Stallions departed the USS *Nimitz* for a point in the Iranian desert more than 500 miles away. At a remote location designated Desert One near the Iranian town of Tabas, they would meet their strike force and six C-130 transports, some carrying fuel for the helicopters' next leg. What happened next was the first in a series of mishaps that led to a nightmare.

Aboard each RH-53D was a system called the "blade inspection method," or BIM. Each rotor blade has a hollow spar containing pressurized nitrogen gas; the pressure is monitored by a gauge wired to a warning light. If a spar cracks, the gas leaks, and the BIM gauge warns the pilot that the rotor may fail. Now one of the pilots was staring at just such a warning light. Although others later second-guessed his decision, he put the Sea Stallion down and waited while another helicopter in the formation stopped to get him and his crew.

Then another RH-53 lost some of its instruments and turned back to the *Nimitz*. Now they were down to six helos, the minimum required to accomplish the mission. Unforecast dust storms scattered the flight, and when the helicopters arrived at Desert One, the ground commander of the operation, Colonel Charles Beckwith, noted (as he wrote in his book *Delta Force*) that they seemed to come in from all points of the compass. And they were over an hour late. As Beckwith ordered his force on to the helicopters for a flight to the outskirts of Tehran, he got a final piece of bad news: another RH-53 equipment failure, this time a hydraulic system. Beckwith aborted the mission, hoping to avert losses and get his people out. But in the darkness, a hovering RH-53 struck one of the C-130s, and Beckwith heard a muffled explosion. A fuel tank had ignited.

Eight people died before the rest could escape the carnage, and 52 Americans in the occupied embassy in Tehran spent another night with their captors. President Jimmy Carter faced the public on TV the next day and took personal responsibility for approving the plan to rescue the hostages. Perhaps it

CAMERON DAVIDSON (2)



*V-22s being tested at the Patuxent River base in Maryland are basically production aircraft. A team of pilots like Marine Major Kevin Gross (above) and maintenance personnel from the V-22 user services (right) has been evaluating the Osprey to ensure it meets their requirements. At airspeeds in the conversion corridor, the controls change modes to enable the craft to transition from airplane flight (below) to a hover, during which the V-22 can be flown like a helicopter (opposite).*

ERIK HILDEBRANDT

ERIK HILDEBRANDT

is just coincidence, but about a year later, the United States took the first steps toward developing an aircraft that would become the V-22 Osprey.

To this day, when the brass briefs on the V-22, they point out how the rescue in the Iranian desert might have gone if they'd had the right aircraft.

Because of the limitations of the RH-53's range and speed, they say, the rescue had to be performed in stages. Too many stages. The plan violated the KISS Rule: Keep It Simple, Stupid. Under cover of darkness, the helicopters were to meet the C-130s, refuel, board the troops, move to a hiding place (Desert Two), and wait through the daylight hours of the second day in concealment. At nightfall, the troops would move by truck to the embassy, execute the assault-and-rescue operation, meet the helicopters, reload, then fly to an airstrip to meet some C-141 jet transports, which would speed everyone to safety. Next slide, please.

Here's the same mission but with V-22s instead of RH-53s and C-130s. One: V-22s fly nonstop from *Nimitz* to assault staging area near embassy. Two: Team prepares for assault. Three: Team assaults embassy. Four: Team and hostages board V-22s and fly back to *Nimitz*. There may be glitches, but the V-22s' backup systems do their jobs. It's over in eight hours, and who knows? Maybe Jimmy Carter gets re-elected.

But in 1980 the concept of a tiltrotor airplane, or convertiplane, that could use twin rotors to lift off vertically and then rotate the rotors so they function as propellers while wings provide lift was nothing more than a 30-year-old idea. A number of similar machines had been developed for research, mainly to evaluate schemes for controlling such an unconventional machine.

The mid-1950s through mid-1960s saw hybrids like the British Fairey Rotodyne, which combined a traditional lift rotor and a wing with propellers for forward thrust. Bell's XV-3 and X-22A were tiltrotors, the latter with ducts around the blades, while Boeing's VZ-2 and the LTV-Hiller-Ryan XC-142 were tiltwings in which the entire wing, together with engines and propellers (four of them on the -142), rotated as a unit. All these machines were conceived be-

VERNON PUGH

CAMERON DAVIDSON

*With inflight refueling (above), the V-22's ultimate range is limited only by the availability of tankers. The Allison engines (left) are similar to those on the C-130 and on regional airliners. Bell Boeing senior test pilot Bill Leonard (opposite) quips that in some flight situations the V-22's computers "outvoted" him.*

cause the helicopter, a machine designed to hover, has an irreparable flaw when it tries to fly forward at high speed.

Hovering in still air, the helicopter is happy—everything is balanced and symmetrical, with the rotor blades creating equal lift throughout the circle of their revolution. To move forward, the pilot pushes the cyclic control, or stick, toward the nose, which causes the swash plate in the rotor head to increase the pitch of the rotors when they are swinging through the aft portion of the circle. The effective lift of the rotor system tilts forward, and the helicopter gently begins to accelerate. As its airspeed increases, the air flowing over the rotor blades begins to create an imbalance. The rotor blade that is advancing into the relative wind encounters a net gain in lift due to higher speed over its airfoil. The retreating blade encounters a net loss, and this divergence eventually increases until the retreating blade can no longer create sufficient lift and the aircraft rolls off toward the retreating blade even if the pilot tries to counter the roll with the cyclic control. This phenomenon, retreating blade stall, limits the top speed of traditional helicopters like the RH-53.

The tiltrotor effectively trumps this effect by turning the rotor into a propeller. No more advancing blade, no more retreating blade, just simple thrust, and all of it moving the airplane forward, supported on its wings. As Bill Leonard, Bell Boeing senior test pilot for the integrated test team from all three services that will operate the Osprey, puts it: "Don't think of this thing as a helicopter. Think of it as an airplane that hovers."

It is also important to think of it as an invention and to recognize the V-22 as the first wholly new aircraft configuration in the sky since the Harrier—the British jet that can take off and land vertically—which entered service in 1970. (Accordingly, last August, the Federal Aviation Administration issued its first powered-lift ratings—specifically for tiltrotor aircraft—to eight V-22 test pilots.) While much of the inventing was accomplished by research aircraft, most significantly Bell's XV-15 for NASA and the Army, the final design of the V-22 has benefited enormously from the march of technological development in the broader fields of ma-



*For more on the V-22, visit the Web at* www.airspacemag.com/ASM/mag/supp/ON98/Osprey.html

terials, electronics, and computer software. In fact, the aircraft that will be fielded first to the Marines as the MV-22 (the Air Force version is the CV-22; the Navy's, the HV-22) represents a wiser design that has benefited from some of the delays that have affected the program. The first prototypes were all-composite, but the decision to mate advanced composite materials with more

CAMERON DAVIDSON

traditional aluminum in the production aircraft, to cite just one example, appears smart: The most recent engineering and manufacturing development (EMD) aircraft are lighter and cheaper to build than earlier prototypes.

After the XV-15 showed that a tilt rotor aircraft could evolve into something more than a research platform, the next step was to build and fly six full-scale development (FSD) prototypes of the V-22. Although the program began as the JVX in 1981 under management of the Army, the Navy and Marines took over early in the game, with the Air Force as an interested partner looking at a smaller number of a special long-range V-22 version for the U.S. Special Operations Command, a combined force that would be called upon if something like the Tehran situation arose today.

Bell and Boeing formed a joint venture to build the craft in 1982, and a year later received a contract. Peering into the future, the Marines were especially anxious to replace their medium-lift Boeing Vertol CH-46 Sea Knights, a large, tandem-rotor helicopter designed and built in the 1960s, battle-tested in Vietnam, and refurbished, renovated, and rebuilt more often than George Washington's hatchet. The average Sea Knight is about 30 years old.

Crashes claimed two of the FSD prototypes. Following uneventful first flights in 1989, initially as a helicopter and later as a fixed wing, the first loss occurred on June 11, 1991, when one aircraft crashed due to incorrect wiring in the flight control system. The loss of a second aircraft and its crew on July 20, 1992, dealt the project a severe setback. While on approach to Quantico, Virginia, a series of component failures in one engine nacelle ignited a fire. Testing was halted pending an investigation and a redesign of the failed parts.

The V-22 program hit another rough patch in 1989, when Secretary of Defense Richard Cheney canceled it during the budget balancing battles of the early Bush administration. While the Reagan administration had allocated almost $1.5 billion for research and production, Pentagon analyst David Chu convinced Cheney that the V-22 was unaffordable. Chu and Cheney wanted more helicopters instead.

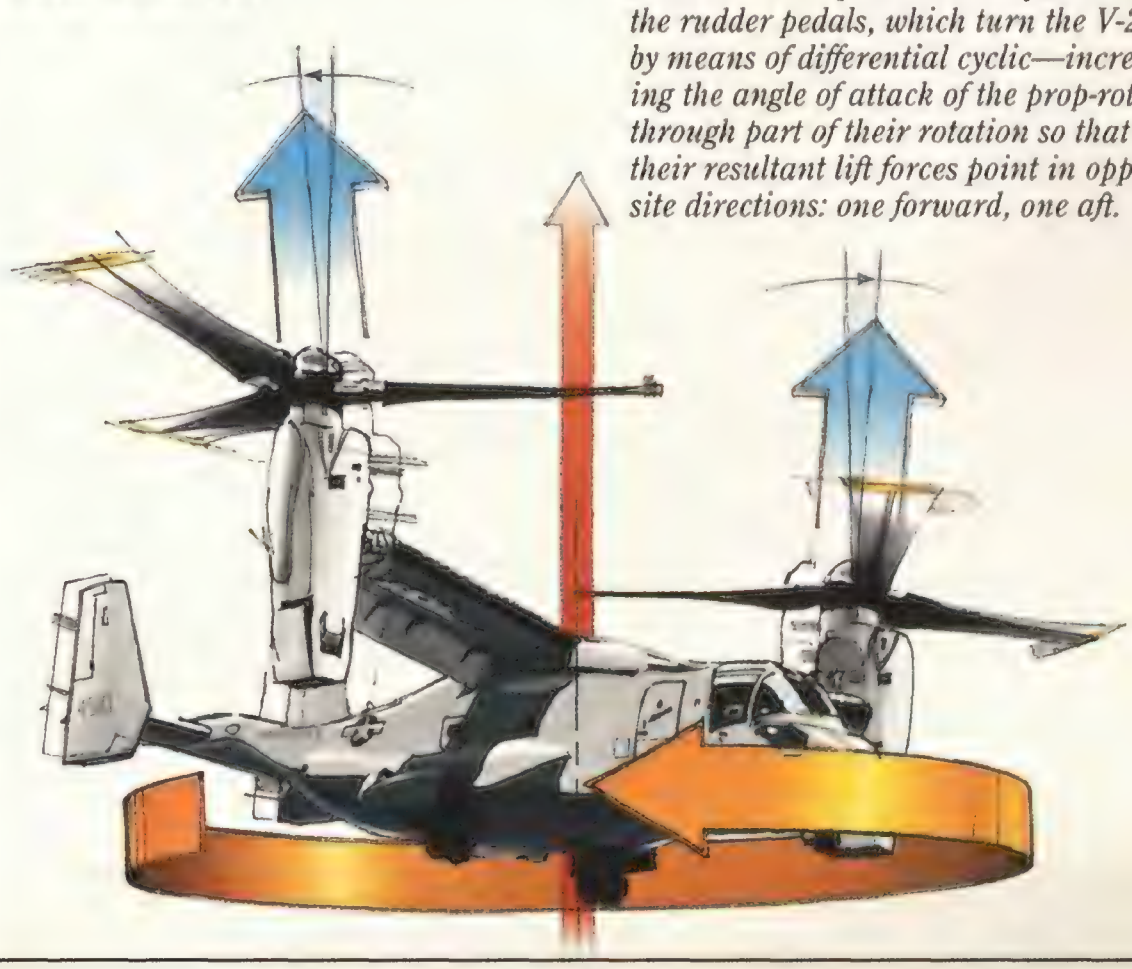
In his first appearance before Congress as the civilian head of defense, Cheney was mindful of enormous changes in global politics. A new Soviet leader named Mikhail Gorbachev was charming Americans, who were beginning to see their former adversary in a new light, and a budget balancing law called Gramm-Rudman-Hollings was pressing Cheney to make cuts in defense. At a hearing before the House of Representatives' National Security Committee on April 25, 1989, he testified in part: "...we opted to stay with established weapons programs where production lines are operating efficiently rather than pursue the development of unproven technology."

But Congress wouldn't allow the V-22 to die, perhaps because some members had not forgotten Tehran. Also, there were election districts and states that had a lot to lose if the project were terminated, and Congress ordered Cheney to restore funding. A timely independent study stated that the tiltrotor concept was the best solution for the future Marine mission. The V-22 was alive, but those charged with its care and nurturing would proceed with a degree of caution that prevails even today as aircraft numbers 7 through 10 undergo testing at Patuxent River Naval Air Station in Maryland. Though the budget now looks bulletproof and the first parts for production aircraft are

ILLUSTRATION BY HARRY WHITVER

***Yaw Control***

*In a hover, the pilot controls yaw with the rudder pedals, which turn the V-22 by means of differential cyclic—increasing the angle of attack of the prop-rotors through part of their rotation so that their resultant lift forces point in opposite directions: one forward, one aft.*



coming off the line, there seems to be a common understanding among the test team on one point: no mistakes. "Just one drop of rain and they don't fly," say people in the test crew, and that's only partially an exaggeration: The instruments on the test aircraft can be ruined if they get wet.

Not that Ospreys are prone to crash; they're even difficult to shoot down, mainly because of inherent damage tolerance built into the aircraft and two or more of everything that you absolutely need to stay in the air, beginning with the engines. A pair of Rolls-Royce–Allison T406-AD-400 turboshaft engines rated at 6,150 (and capable of nearly 7,000) shaft horsepower powers the craft through a system of shafts and gearboxes that can provide power to both rotors if one engine is lost. The engines are offspring of the proven T-58 turboprop, and its cousins are flying in the C-130 Hercules. The Osprey cannot land as an airplane because its 38-foot-diameter rotor blades would strike the ground, but the designers have already thought about the unthinkable: If, for some reason, the rotors won't transition into helicopter mode for landing, the graphite-and-fiberglass rotor blades will not fragment on impact but instead will "broomstraw"—reduce themselves to a bundle of fibers like a straw broom flailing harmlessly at the asphalt. In a crash, the wings are designed to fail and separate from the fuselage, and the nose has a tilted bulkhead that works like the upturned tip of a ski to keep the airplane from flipping over if the nose tries to dig in. The structure is designed to tolerate battle damage and keep flying, and critical parts as well as both pilot seats are armored.

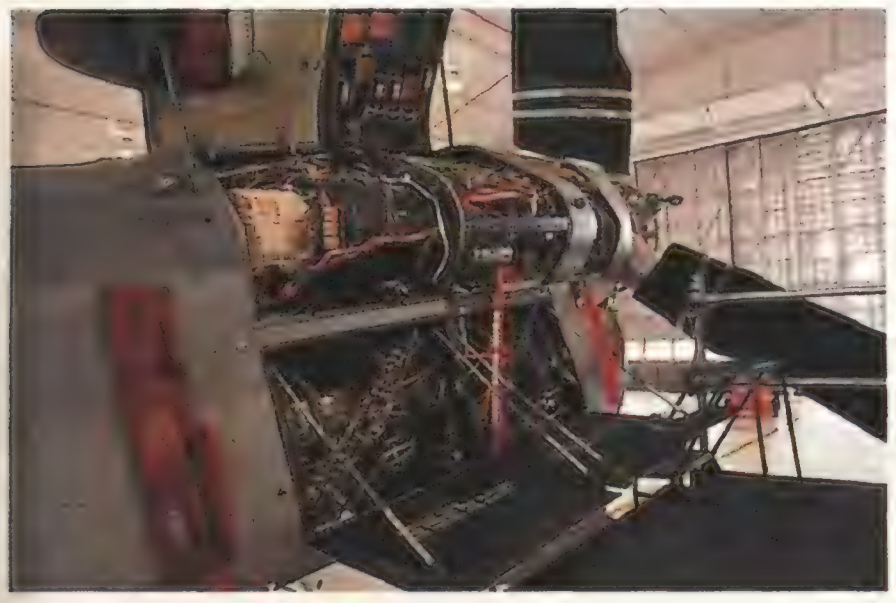
The MV-22 is designed to hold 24 fully armed Marines (and there's a seat for the crew chief), equivalent to a reinforced rifle squad, but the airplane's size has been defined by the vessels from which it will operate: amphibious assault ships, which resemble traditional straight-deck aircraft carriers but with shorter stern portions that are high and square. John Buyers, an easygoing Texan who serves as V-22 program manager for Bell Boeing, says the 38-foot diameter of the rotor blades is mandatory, defined by a required blade tip clearance of 12 feet, eight inches in the vicinity of these ships' islands and five feet from the wheels to the edge of the deck. "If we could have, we'd have made the rotors bigger," he says. "Optimum would have been about 43 feet," adds Boeing senior manager Gregory McAdams. So where did they get 12 feet, eight inches? "That was the CH-53's actual blade tip clearance, and the Navy just didn't want to give up any more than that," says McAdams. While the rotors defined the overall size and weight of the Osprey, its cabin interior dimensions are almost the same as those of the CH-46, which it will completely replace by about 2010.

A ramp folds down at the rear to accommodate two utility vehicles, and the craft has two belly hooks so that it can carry cargo on a sling beneath it. Once aboard a carrier, the Osprey takes only 90 seconds to fold into a package slightly longer than its 57-foot, four-inch fuselage. Although the equipment for the stowing cycle exacts a penalty in weight and cost, self-stowage means that more aircraft can be carried, and all can be launched and recovered within minutes. The Osprey can be refueled in flight through a probe, and it carries a rescue hoist plus a "fast rope"—the line commandos slide down when they arrive in their special way. With inflight refueling, the V-22's ultimate range depends only on having enough tankers and on how long the crew can stay awake. Fuel tanks are located in the sponsons and the wings (plus three

*Trailing edge flaps deploy automatically (right) to smooth airflow over the wing at low speeds, while pendulum dampers on each prop-rotor hub nullify vibration. Access doors double as platforms for the crew to stand on (opposite, top). A powerful screw drive controls the angle of nacelles (opposite).*

that can be installed in the cabin for transoceanic trips). Should gearbox lubricant be lost, the craft can fly another 30 minutes.

The Osprey has three independent flight control systems, any one of which can fly the aircraft. All three use fly-by-wire technology that employs electronic signals rather than cables and pulleys to operate the controls. There are two mission computers and three inertial navigation systems to help you figure out where you are, and the displays in the glass cockpit can be routed to any of the video tubes in the event one of them fails. All information for a mission can be loaded in seconds from a cartridge that plugs into a computer system. In addition to the various alerts and warning lights, an audio annunciator tells you what kind of trouble you're in. (The disarmingly dulcet voice belongs to Barbara Smith, deputy to Colonel Nolan Schmidt, the Marines' program director for the V-22.)



There are four electrical generators, two located with the engines and two more in the upper fuselage, and a battery good for 20 minutes of flying if all else fails. An onboard generator extracts nitrogen gas out of the air and floods the fuel tanks, displacing oxygen and reducing the risk of fire. The outer skin has a fine copper mesh embedded in it to form a conductive path in the event of a lightning strike. The aircraft has three completely independent hydraulic systems, which operate at 5,000 pounds per square inch; out in the fleet, only the F/A-18 has such high hydraulic pressures. But the V-22's hydraulic lines are made of titanium, which is thinner and lighter and thus saves weight. "We had to invent the connectors for that system," Buyers says. The engineers also had to rewrite all the criteria for replacing a line that has been scratched or nicked.

CAMERON DAVIDSON (3)

A little less than half the airplane is manufactured of composite materials, which, while incredibly light, are also corrosion-resistant and strong. Should a bullet penetrate it, the composite fibers ensure that the hole won't expand or start to crack. Systems and controls are distributed and separated throughout the aircraft so that one bullet can't take out all of anything. When things fail, they fail "softly"—only half a control surface at a time, for example.

If all of the systems, capabilities, protection, and toughness seem hard to believe, consider this: The V-22 is an aircraft of the '90s, and the aerospace industry never stands still. Things have changed. At the old Vertol (now part of Boeing) plant in Philadelphia, where workers are building the first parts, there's little of the old din of metalworking; all those industrial sounds have been replaced by the softer whirring of electric motors, fans, and the actuators in robots. The workers here behave as if they're working on the hottest project in aerospace. There's the razor-sharp young engineer, Ken Eland, who is revolutionizing the way the Osprey is built. The company saved $21 million by eliminating the traditional mock-up and so far has cut the parts count by 36 percent, eliminating 18,000 fasteners by such simple steps as making the skins and their stiffeners as a single integrated part.

And there's Valorie Bring, a former IBM employee who says she sort of fell into her current job of designing displays and switches and controls that the pilots can understand and use easily. She uses the word "customer" a lot. She's in charge of the Osprey's cockpit environment and co-author of a paper on how the entire electronic system works on a hypothetical mission. But her biggest job is to listen. "Ask 10 pilots and you'll get nine opinions, and then that one guy will change his mind," she says. "The trick is to find the common thread in their words."

You find the same culture at Pax River. In the hangars where the V-22s are tended between flights, the test aircraft are helpless giants with their innards exposed and people crawling all over them. They remind you of patients in an intensive care ward, surrounded by scaffolding, lines, and service carts. The military officers in khakis and olive

flightsuits and black shoes mix with civilians wearing Nikes and sporting the occasional tattoo or piercing, while out in the parking lot there are motorcycles scattered among the pickups and sports cars and imports. You wondered where the new generation was headed? They're hard at work on the V-22.

While the basic principle of tilting the props to create an airplane that can hover seems obvious, it is not easy to design and build a craft that can do it successfully, as testified by the long line of research aircraft that have led up to the Osprey. The V-22 succeeds in large part because of small, lightweight, powerful computers that can store complex control laws to guarantee success in the hands of an average pilot. When the first Marine service pilots begin flying the V-22, the airplane's flight control system won't let them get into trouble. Bell Boeing senior test pilot Bill Leonard puts it this way: "There are three computers and a pilot, and all of us get one vote. There have been many times when I have been outvoted."

The engine nacelles are controlled by a small knurled thumbswitch on the thrust control lever in the pilot's left hand. The nacelles can rotate from zero degrees—straight ahead in the propeller position—to plus 95 degrees—slightly aft of straight up so that the lift force pulls toward the tail of the airplane to slow down and even back up. A huge screw drive rotates the nacelles at up to eight degrees per second, and conversion can take as little as 12 seconds. Leonard says, "From about 60 degrees nacelle to 95, it flies like a helicopter. From 30 degrees down to zero, it's an airplane." (In the transition, it's a little of both.) In helicopter mode, the prop-rotors have full cyclic and collective controls using the stick and thrust control lever (TCL), respectively. "You use your left hand [TCL] to control altitude—the vertical—and your right hand [stick] to control your position in pitch and roll," Leonard says. The foot pedals control the yaw axis, which works in helicopter mode by diverging the lift axes of both rotors, just as it works on a tandem-rotor helicopter like the CH-46 (see "Yaw Control," p. 31).

At between 40 and 80 knots forward speed (the Osprey uses knots, which equal 1.15 statute miles per hour, for airspeed measurement), the wing begins to produce lift and the airplane control surfaces—ailerons (in this case, combined flaps and ailerons called "flaperons"), elevator, and rudders—begin to have an effect. At the same time, the helicopter controls begin to phase out of the prop-rotors, and at about 100 to 120 knots, they become propellers. The airplane's genius is in phasing from one mode to the other based upon flight conditions, mixing the controls so that both are active in the region between about 40 and 120 knots. The pilot can rotate the nacelle forward with the thumbswitch or, while accelerating, let the computer do it. During deceleration the pilot must rotate the nacelles to the vertical with the thumbswitch; otherwise, with the power pulled back, the V-22 will slow and eventually stall.

Where Leonard and other pilots may occasionally get outvoted by the three computers is in a region called the "conversion corridor." The corridor is a programmed schedule of airspeed-nacelle angle combinations that prevent the rotors from being overloaded at high speeds. The computer won't allow the pilot to rotate the nacelles back toward upright until the airspeed drops below 220 knots, for example. It will also move the nacelles from five degrees to zero automatically in airplane mode.

In the V-22 simulator at Pax River, Major Kevin Gross, a U.S. Marine with the integrated test team of V-22 pilots, lets me have a go at it. The cyclic control in my right hand feels like any military control stick, with switches and buttons arranged around it and a four-way "coolie hat" switch near the top to trim out imbalance in pitch or roll. But the thrust control lever in my left hand is different, more massive than any throttle or collective I've ever gripped. Instead of moving up and down like a helicopter's traditional collective, the TCL moves fore and aft, like a throttle, yet it feels natural to pick up to a hover by pushing forward to add power.

Normal takeoffs are made not from a hover but with the nacelles at 60 degrees. The airplane rolls for a short distance, and once aloft, I begin pushing forward on the thumb switch to rotate the nacelles forward. The nose dips a bit during the transition, and with Gross coaching me, I add a little bit of back pressure. Within a few seconds we are in a cruise climb at 180 knots. At five degrees nacelle, I can let go of the button and the nacelle will continue auto-

CAMERON DAVIDSON

*Bell Boeing program manager John Buyers (above, at left) reviews plans as technicians work from a cherry picker. The Osprey is waterproof, but the test instruments are not, so flights are performed in fair weather (right).*

matically to zero. Push the button once more and the rotor slows to 84 percent rpm and we are a pure airplane.

"It doesn't do loops, and it really doesn't do aileron rolls very well. It'll do a wingover," Gross says. Then, with the nacelles set at 95 degrees, Gross flies up the runway's electronic glide path backward, just to show that backing up can be done with an added task like shooting an instrument approach. These are the simple pleasures of the test pilot life, and Gross is quick to add, trying to keep a straight face, "This will not be normal procedure."

Has he ever done an autorotation, the power-off maneuver in a helicopter in which the rotor blades freewheel in a descent to an emergency landing? His cautious answer: "Autorotation has been evaluated. Actually there are three phases to autorotative descent. The entry to the autorotation, the descent itself in a steady-state condition, and then there's the flare at the bottom. We have done the autorotative descent in flight test. The entry and the recovery still have yet to be done, and I don't know if we actually will in EMD or not. That's a pretty big decision above our pay grade." Gross explains that this rotor system is not like a helicopter's in that the system is not free-turning with power off and there is not the same collective power to flare with at the bottom by pulling the blades to abnormally high pitch angles.

On the way home from the simulator flight, it dawned on me that the test pilots are continuing the process of invention: They are inventing how to fly the thing. Someday soon, someone will have to sit down and write a pilot operating handbook. Gross and his colleagues on the test team talk frequently about the coming day when the "lieutenants" get the airplane—"When the lieutenants fly it...," "We wonder how the lieutenants will handle this...."

They freely speculate about some of the things they've done with the V-22, exploiting its talent for hovering in a very stable manner while they use the nacelle switch to alter the deck angle of the fuselage, a condition in which both pilots are looking down at the runway, which fills the windshield at a startling angle. "No other aircraft can do this," they say. But they don't know how many of these capabilities will make it into the syllabus and be taught when they "take it to the schoolhouse"—their term for flight training.

They are surely aware that Marines inevitably discover the unusual corners of any aircraft's flight envelope. The British invented the Harrier, but a U.S. Marine invented "viffing," or vectoring in flight. No one had thought to try moving the nozzles of the jets' engines at high speed. It turns out that the use of this peculiar talent can make the Harrier a very difficult target to hit in aerial combat. The service pilots on the V-22 test team tacitly accept that this aircraft will perform feats as extraordinary as its appearance.

Residents of the coastal Carolinas will soon start seeing the V-22 in the skies near Marine Corps Air Station New River near Camp Lejuene in North Carolina. They are likely to stop their cars, jump out, and stare. Switchboards will light up all over Onslow County with reports of alien craft that look like two windmills attached to a big gray schoolbus with a forked tail.

And perhaps someday, a lonely gunman walking guard on American captives in a besieged embassy will hear a soft whirring sound in the night that comes closer and closer until suddenly he is faced with an apparition that stares back as if to say, *Hey, buddy, hostage THIS!*

VERNON PUGH

# WHOSE PLANES ARE THEY, ANYWAY?

Yours. But salvors, collectors, and scholars are all claiming custody in an angry fight over rare warbirds.

by Carl Hoffman

*Photographs by Cameron Davidson*

The treasure that set off a lawsuit and commanded front-page headlines hardly looks worth fighting for. Wingless, corroded, ripped open on its starboard side, the Grumman F6F-5 Hellcat sits in a cold, damp corner of the Quonset Air Museum, a decrepit hangar on the former Quonset Naval Air Station in North Kingstown, Rhode Island.

"She's amazing, isn't she?" says Larry Webster, stroking the weathered fuselage.

The airplane was discovered in the summer of 1993, when a National Guard helicopter crew spotted what appeared to be a downed airplane in the waters just off of Martha's Vineyard. A diver dispatched by the Coast Guard found an old wreck (of obviously no importance to the Coast Guard) and contacted Webster, one of a handful of volunteers who run the Quonset museum. A round, jovial amateur aviation archeologist and warbird buff who has been poking around Rhode Island crash sites since he was a boy, Webster was burning for a big find. And when it turned out that the wreck was in fact a rare World War II fighter, Webster felt like he had struck paydirt.

Quonset contacted the Naval Historical Center in Washington, D.C. Forget it, the center said. The plane was Navy property. Quonset was forbidden to recover it.

But the guys at the museum couldn't help themselves. "We were just too excited," says Webster; "we went out and did it anyway." And who could blame them? Professional salvors with huge budgets were scouring the ice caps of Greenland and the depths of Lake Michigan searching for rare airplanes like the Hellcat. Of 12,275 produced during the war, only 20 remained. And one was right there in Quonset's own backyard.

*In addition to the gleaming examples of vintage aircraft in its main building, the Navy's air museum has a shack full of extras (left). Despite this bounty, museum officials want control over all old U.S. Navy airplanes, even those long abandoned.*

Besides, this was hardly a gang of privateers. Quonset is a small, non-profit museum, and it already had airplanes on loan from the Navy. The salvors just wanted to restore the plane for display there. The pilot had been a local boy, and though his body had never been found, his family was grateful to at least learn the fate of his plane. Local businesses donated services, and the Rhode Island National Guard transported the airplane to the museum.

Within days agents from the Naval Investigative Service came calling. If the Hellcat wasn't immediately shipped off to the Navy's National Museum of Naval Aviation in Pensacola, Florida, there'd be hell to pay. Piracy. Theft of government property. Disturbing an archeological site.

"They insisted that an airplane that had sat in shallow water just off shore for 48 years was not abandoned," says Webster. "We went out and recovered it and spent our own money and then they claimed it was theirs."

Quonset contested ownership in court, but eventually the museum and the Navy reached a compromise. The Navy retained ownership but agreed to let Quonset restore and display the airplane on a long-term loan.

This was not the first time the Navy had threatened a salvor with criminal prosecution, nor would it be the last. In recent years, the disposition of old Naval airplanes has pitted the Navy against warbird enthusiasts, setting off volleys of angry accusations and protracted legal battles.

The Navy's position seems clear enough. "Department of the Navy ship and aircraft wrecks are government property in the custody of the U.S. Navy," states the Navy fact sheet entitled "Sunken Naval Vessels and Naval Aircraft Wreck Sites Policy." "As part of its custodial responsibilities under the

National Historic Preservation Act, the U.S. Navy is obligated to protect its historic properties, including ship and aircraft wrecks. The above act tasks federal agencies to manage their cultural resource properties in a way that emphasizes preservation and minimizes the impact of undertakings that might adversely affect them."

Says Doug Champlin: "The Navy's policy is 'We don't need 'em but you can't have 'em.' " Champlin is the owner of the Champlin Fighter Aces Museum in Mesa, Arizona, the world's largest private collection of fighters. "People are finding all kinds of Navy airplanes but they're having to leave them underwater and that's counterproductive," he says. "In a few years all that will be left is a pile of corrosion."

"The argument is made that the Navy is ignoring the planes and they're rusting, when private salvors and collectors could preserve them and show them off," acknowledges Captain Robert Rasmussen, director of the National Museum of Naval Aviation. "My counter to them is: 'You give me a sound plan to pull them up and maybe I'll let you do it and then loan it to you.' But that's not so attractive because they can't make any money out of it."

According to a form letter the Naval Historical Center sends out to those interested in going after old Navy planes, salvors must first submit a "thoughtful and thorough plan which takes into consideration the documentation, recovery, conservation/restoration, preservation, and final exhibit of the aircraft in question. Also required is a financial plan which provides detailed information on project costs and funding sources." And if any wreck site is over 50 years old, "Section 106 of The National Historic Preservation Act of 1966 must be complied with through a review of the aircraft's potential eligibility for the National Register of Historic Places." And then the museum in Pensacola and the U.S. Marine Corps Air-Ground Museum in Quantico, Virginia, "must be allowed to exercise their guaranteed rights" of first and second refusal of the airplane.

Salvors and collectors say they understand the Navy's anxieties. "We don't want a bunch of cowboys out there with grappling hooks any more than they do, and of course the Navy should have the right of first refusal, but the private sector is well equipped to get these planes," says Champlin.

"I can see the Navy invoking its ownership when there's only one known example of a TBD, for instance," says salvor and restorer Roy Stafford. "But I don't see it when you've got umpteen Hellcats and Wildcats and SBDs. Does it protect national treasure or just keep private enterprise out?"

Not all military services protect their old property as aggressively as the Navy does. If you're dead-set on recovering a B-29 stuck on a frozen lakebed in northern Greenland or a P-38 rotting away on the Aleutian Island of Attu, the Air Force couldn't care less. "You asked if it is possible for a civilian to obtain permission to recover and gain title to the P-38 on Attu," the Air Force Materiel Command wrote salvor David Mahre in 1995. "Aircraft that crashed before 19 November 1961, when a fire destroyed the pertinent Air Force records, and that remain wholly or partially unrecovered, are considered formally abandoned. The Air Force neither maintains title to, nor has property interest in, these aircraft." The policy underwent a top-level review in 1994 and emerged unchanged, with one exception. If human remains are discovered at the site, government personnel must be allowed to remove them before the salvors can continue working.

The government of Canada is also willing to let private salvors go after old military aircraft. Says Major Dan Bellini, Director of Disposal, Salvage, Artifacts and Loans at the Canadian Department of National Defence Headquarters: "Although the Crown maintains ownership of all Canadian military wrecks, the Department of National Defence grants salvage rights and title to individuals."

But the U.S. Navy has long been ambivalent. Many times it has fought fiercely to control its underwater property, claiming that it is not subject to traditional admiralty law. In essence, that law says that if a salvor finds something on the high seas, he is entitled to one of two things. If the property has been abandoned, the salvor can keep it. If, on the other hand, the property still belongs to someone, the salvor must get

*Three constituencies with passionate views on warbirds: Quonset Air Museum's Larry Webster (opposite, right) and Mark Newton, standing up for independent, non-profit museums; the Naval Historical Center's Robert Neyland (right), for whom archeological documentation is critical; and private collector Doug Champlin (below), who fears the ravages of corrosion—and the efforts of competing salvage teams.*

"liberal compensation" from the owner for returning it. By claiming "sovereign immunity" from this salvage law, the Navy has staked out its own legal position: Without the Navy's permission, no one may salvage a piece of Naval property, even if the Navy has clearly abandoned it.

But ownership apparently does not confer responsibility. In 1944 and 1951, when it was sued in federal court by the owners of fishing vessels damaged in the Chesapeake Bay by the sunken carrier USS *Texas*, the Navy claimed—successfully—that because it had long ago abandoned the carrier, it was not responsible for any damage it did.

To confuse matters further, on some occasions the Navy has readily ceded control of its underwater property. In 1978, salvor Gary Larkins (see "Gary and the Pirates," Feb./Mar. 1997) and his friend Dick Wauters were towing a side-scan sonar through Lake Washington, near Seattle, when they found, among other planes, two Goodyear-built FG-1D Corsairs. They made a videotape and took it to Captain Grover Walker, then director of the National Museum of Naval Aviation, and asked if he wanted them. "What the hell would I want a Corsair off the bottom of Lake Washington for? I have five in the museum," Larkins remembers Walker saying. "He was realistic about the whole thing and said that as long as the planes went to an approved museum, then I could go recover them." Larkins pulled up one of the Corsairs, which today graces Seattle's Museum of Flight.

"If I had a plane that the Navy museum wanted, then Walker would make you a deal on it," says the salvor. But if the museum didn't need the plane, it had no objection to Larkins bringing it up for another museum to display. "The system worked and it worked well," he says.

The museum in Pensacola is the Navy's biggest recipient of historic aircraft. A gleaming monument to Naval aviation, it draws over a million visitors a year. Blue Angels A-4 Skyhawks hang from a seven-story steel and glass atrium, and the museum's west wing houses a replica of the flight deck of the World War II-era USS *Cabot*, where Hellcats, Wildcats, Dauntlesses, Corsairs, and Avengers are all on display.

"The salvage of underwater aircraft has been unimaginably important" in developing such an impressive collection, says current museum director Robert Rasmussen. "I can point to at least 10 airplanes that are on display right now that have been salvaged, and the only reason we have any airplanes that actually took part in World War II is because they came out of Lake Michigan."

SCOTT HIGHTON

A quiet, soft-spoken former Blue Angel who paints aviation scenes in his spare time, Rasmussen took over the museum directorship from Walker in 1987. Soon after, he got wind of a recovery operation in Lake Michigan being run by Al Olson and Taras Lyssenko. In the 1980s the two buddies spent their spare time looking for treasure in Lake Michigan, where the Navy had conducted carrier training exercises during World War II. Part-time hobby though it was, they found the remains of some crashed or ditched airplanes, well preserved in the lake's frigid, fresh water. When A & T Recovery, as Olson and Lyssenko called the salvage company they formed, brought up a Douglas SBD Dauntless dive bomber and a Grumman F4F Wildcat fighter for loan to the Patriots Point Air and Space Museum in Mt. Pleasant, South Carolina, word reached Rasmussen. "These were some of the most important planes to the history of Naval aviation and I didn't have examples of either one," says the director. "I rescinded my predecessor's position and took an interest in underwater aircraft."

Salvaging airplanes, however, takes money—lots of it. Sometimes, as an alternative to cash, clients arrange to pay for salvaging services with an item that the salvor wants: either part of the treasure being salvaged or something else, such as a piece of equipment the client deems obsolete or surplus. But U.S. law permitted the museum only the exchange of one item for another, not an item for a service. Rasmussen appealed to his Congressman, Earl Hutto, and in 1988 Congress passed a law that permitted the museum to exchange equipment for salvage services.

Initially the trading went well. In the first trade with the museum, which cen-

COURTESY LARRY WEBSTER

COURTESY GARY LARKINS

*Domestic training and patrol missions during World War II left perhaps hundreds of Navy planes in the drink. Forgotten for years, today they are hotly coveted as antiques. Clockwise, from left: a Hellcat, now at Quonset Air Museum, pulled from the waters off Martha's Vineyard; a Wildcat from Lake Michigan; a Corsair from Lake Washington; the only remaining TBD, still underwater off of Miami; and a Dauntless from Lake Michigan.*

tered on a salvage job in Lake Michigan, A & T Recovery received title to two Wildcats (which the company quickly sold, unrestored, for $250,000 apiece) and a Dauntless, while the museum got a Vought SB2U Vindicator, a Dauntless, and a Wildcat.

"Those guys at the museum became a bunch of horse traders," laughs Lyssenko.

"The trading program has been the lifeblood of this museum," Rasmussen acknowledges. "Without it, our collection wouldn't be half of what it is."

And then the trades began to sour.

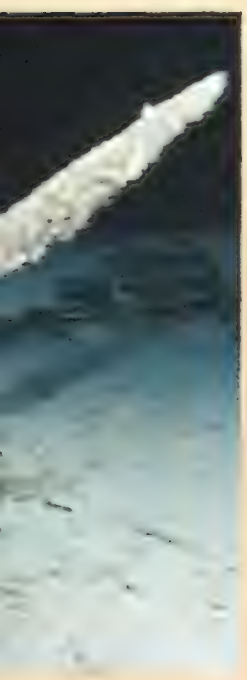
One of the first to go bad got started in 1991, after New York-based treasure hunter Robert Cervoni stumbled upon an airplane some 500 feet underwater off the coast of Miami. He sent video footage of the wreck to Roy Stafford, whose Black Shadow Aviation had restored many of the Pensacola museum's airplanes recovered from Lake Michigan. *Bingo!* thought Stafford the moment he saw the tape. "It was the Holy Grail of Naval aviation," he says, the only known Douglas TBD Devastator in the world. Not only that, but it appeared that the torpedo bomber may have been the sole survivor of the 1942 Battle of the Coral Sea, a vicious engagement in the Southwest Pacific in which Japan sunk three U.S. Navy ships, including the carrier *Lexington*. The plane was priceless, says Stafford. He set up a meeting between Cervoni and Rasmussen, during which Cervoni offered to sell the coordinates to the Navy for $25,000.

"I got pretty excited," admits Rasmussen, but he adds that the Navy could not respond immediately because it would have first had to conduct "a thorough examination of the feasibility and cost of a recovery and the viability of the aircraft for recovery."

After waiting several months for the Navy to respond, Cervoni sold the coordinates for $75,000 to Doug Champlin. Champlin then approached Rasmussen with a proposal. "I needed a Wildcat for my collection and the museum had a bunch of them from Lake Michigan," he says. "I said I'd deliver the TBD to the dock in exchange for one of the Wildcats. It was a win-win situation for both of us.... That TBD was worth $2 million at least and they had Wildcats just sitting in the rain. It wouldn't have cost the taxpayers a cent."

Champlin says that Rasmussen and his deputy, Robert "Buddy" Macon, instructed him to file an admiralty lien on the wreck, which essentially would have prohibited anyone from taking it until


A & T RECOVERY



ROBERT MESTER

GARY LARKINS

the federal admiralty court formally awarded ownership. To place a lien, however, requires a piece of the wreck. Another $55,000 later and Champlin had the TBD's canopy.

Rasmussen recalls the situation differently. For one thing, he says Champlin initially asked for two Wildcats, not one. And he denies telling Champlin to remove the canopy and bring it up, which would have risked damage to the aircraft. "I might have encouraged Doug to bring up a piece [of unattached metal], I can't remember, but that would have made sense and it wouldn't have been unusual," he says. "It's hard to get a real analysis of a plane's condition until you hold it in your hand." Finally, Rasmussen denies advising Champlin to file a lien. That, he says, would have been tantamount to ceding ownership of the TBD to Champlin.

Alarmed to learn that a lien was about to be filed, Navy personnel notified the Department of Justice. According to Champlin, "They [Justice] said if I didn't give the canopy to Rasmussen and the museum immediately, then we'll prosecute you for stealing government property. So I dropped the lien and shipped them the canopy."

Not long after that, another deal went bad. In 1993 Florida salvor Peter Theophanis went to Lake Michigan to look for a particularly sound Dauntless that the museum told him it was interested in. The salvor couldn't find that airplane but he did find its ugly-duckling sibling, a wreck that was little more than a Dauntless cockpit, wings, and landing gear. Significantly, the engine and the fuselage aft of the cockpit had been removed, indicating that the Navy had abandoned the airplane decades before. Theophanis filmed the Dauntless and sent the videotape to Pensacola.

According to the salvor, Rasmussen and Buddy Macon told him that the Dauntless was a piece of junk and that the Navy didn't want it. So Theophanis felt free to bring the plane up and sell it to a private collector. He undertook the recovery openly, confident that he was breaking no laws. But months later, on the day his wife was due to deliver a baby, Theophanis was arrested and dragged away by a black-clothed, machine gun-toting SWAT team from the U.S. Marshals Service. The charges: theft of government property. He wasn't allowed to place a phone call for 13 hours, and he was jailed as a flight risk for two days. (The charges were later dismissed on a technicality, and Theophanis is now suing the Navy.)

"Why didn't they file a civil suit against me to determine ownership?" the salvor asks. "For there to be a crime there has to be intent, and I didn't steal that plane—it was abandoned."

Not surprisingly, Rasmussen's account differs markedly. "He was well aware that he needed [Navy] approval and that he did not have it," the director maintains.

And then, of course, came Webster and the Hellcat and the Quonset Air Museum in Rhode Island.

In all of these cases, says Rasmussen, "we're always portrayed as this big, bad, bureaucratic Navy pursuing these tiny organizations dedicated to the preservation of history. But once Navy policy is violated and the law is broken, we have no choice. These are rare pieces of American aviation history and we have to maintain control of them. I want to have access to them for the museum, and I don't relish seeing them enter the civilian sector, where who knows what will happen to them. Sure, they might be well protected in some private collection, but who's to say what will happen 50 years from now? Maybe the collector's grandson won't care about old airplanes and he'll sell them to Japan."

Rasmussen admits that the museum has more aircraft than it can use. During my visit, he took me to a beat-up shed behind the museum and opened the rusty door to reveal row upon row of weathered Wildcats and Dauntless-

es, even an exceedingly rare Grumman Avenger, their wings still bearing stars and bars—potentially millions of dollars' worth of rare warbirds. "I'd say they're all worthy candidates for loan or trade," Rasmussen says. Indeed, many of the museum's surplus aircraft are on display throughout the country, from the terminal of Chicago's O'Hare Airport to the tiny Quonset museum.

But even though blessed with this abundance, the Navy has grown intensely vigilant over the aircraft that remain underwater. In the last four years, it has approved only one recovery proposal (which eventually fell through). Part of the reason is that another party started keeping an eye on the Navy's submerged relics: the Naval Historical Center.

Located in the Navy Yard in Washington, D.C., a campus of tidy parade grounds, cannon, and two-century-old buildings, the NHC has long been the central repository of Naval history. The center houses the Navy's official library, as well as its official museum. As salvors got wind of the museum's trading, alarm bells started ringing at the NHC.

The NHC's head of underwater archeology is Robert Neyland. A tall man with a formal air, he explains that the Navy's policy is to view every Navy airplane wreck that is at least 50 years old as a potential archeological site to be studied, protected, and considered for placement on the National Register of Historic Places. "We want to document the position of the aircraft in the water, its condition, what was registered on the gauges, the position of the controls—all of the things that give you a sense of it," he says. "I'm not sure that the recovery of a single aircraft will change our major interpretations of World War II. However, finding the location of specific aircraft lost during the Battle of Midway [for example] can provide valuable information about where air battles occurred and planes were lost."

"I'm sorry," responds Taras Lyssenko, "but archeology has nothing to do with these aircraft. The historical center comes up with stuff that's nonsense. You bring up a plane, look at its information plate and number, and then look at its history. The data is all there." Even museum director Robert Rasmussen admits: "It might be stretching it to say that every airplane on the bottom of Lake Michigan, for instance, is a bona fide archeological site. But I guess it's in the eyes of the beholder."

Neyland says that careful documentation will also help future museum managers. "As part of a museum collection, the aircraft may have to be restored not only once but many times," he says. "Questions will eventually arise of what is original and what has been replaced or altered."

*A misunderstanding between salvor Peter Theophanis (below) and Pensacola museum director Robert Rasmussen (opposite) led to Theophanis' being arrested and briefly imprisoned for bringing up a picked-over Dauntless from Lake Michigan. Rasmussen says the museum will trade or loan its surplus inventory (opposite, bottom), but he doesn't want Navy airplanes ending up in what he considers the wrong hands.*


In examining salvors' proposals, Neyland is particularly attentive to the disposition of the airplane after it has been salvaged. He fears that "rash recoveries" that don't include long-term plans will ultimately result in valuable information being lost.

"If someone has a valid proposal and the resources to recover a plane, we don't discourage it," Neyland says. But, he adds, since the NHC became involved in the recovery of Navy aircraft, "none of the salvors have come up to us with a real plan. They're all involved in some speculative venture.... In almost all of these requests, there is no museum identified as willing to take the aircraft and to take responsibility for the conservation, restoration, and exhibit."

After talking patience and the need for careful, professional recovery, the Navy dived into the tricky business of aircraft recovery itself. Back in 1978, Gary Larkins had found in Lake Washington not just a pair of Corsairs but a rare, intact Martin PBM-5 Mariner patrol craft, one of only two known to exist. It was upside down under 70 feet of water, its wings covered with "approximately six feet of silt material," and its recovery would involve "a major degree of difficulty" and a "substantial monetary expenditure," in the words of a salvage proposal that Larkins made to the Pensacola museum in 1982 (the proposal was never approved).

In 1996, a team of Navy divers and salvors went after the PBM. The project was to take two weeks but stretched into eight. When the increasingly frustrated team finally attempted to lift the plane, it broke apart because the silt hadn't been adequately removed. "We canceled the recovery when it became evident it couldn't be done with the assets available," says Neyland, who adds: "In hindsight, [the divers] should have aborted the project earlier in order to do additional planning."

"What the hell was the Navy doing trying to get that plane?" asks Roy Stafford. "They don't have the expertise that a Larkins or I have to safely salvage any-

thing, and they destroyed a priceless airplane."

"I don't know of any [commercial] salvors who could have done that airplane recovery," says Neyland, noting that the PBM-5 flying boat is almost the size of a 737.

Every salvage job represents a unique set of challenges, of course. But Larkins notes that his recoveries have included such enormous craft as the B-29 *Kee Bird* and the B-17 *My Gal Sal*.

In 1996, Doug Champlin, out $130,000 for the coordinates of the TBD and the recovery of its canopy, learned that A & T was planning to recover the airplane for the Pensacola museum.

Lyssenko says that he found the TBD fair and square, maintaining: "Any good survey company can go and find that plane" by towing a side-scan sonar over the approximate location.

"Are you kidding?" responds Champlin. There's no way in a million years, he says, that Lyssenko could have found a fighter 500 feet underwater so quickly. "There's more in this than I'm willing to tell you without proof," he hints.

In any event, not long after, in an effort to raise money for the eventual preservation of the TBD, the museum signed over title to 11 unrestored C-130 Hercules transports to its non-profit foundation, which then sold the C-130s to a California airplane dealer for $200,000. Some estimate that restored, they would be worth almost $10 million. Rasmussen defends the transaction: "The Defense Reutilization Management System valued the planes at less than $5,000 a piece," he says, adding that the airplanes were put up for open bid and went to the highest bidder.

In frustration, Champlin asked U.S. Senator John McCain of Arizona, a former Navy aviator, to look into the TBD saga. McCain's office questioned various branches of the Navy—the legislative affairs office, the NHC, the counsel office—and the Navy, according to a McCain aide who asked to remain anonymous, acknowledged total confusion. At first the Navy hoped that after studying questions about ownership and the use of outside salvors, it would come up with a clear and fair policy by the fall of 1997, the aide says. But "it's a convoluted issue and much more complicated than we thought, and now the Navy says it hopes to have a policy in place by the end of the year." Until the Navy resolves the issue, it maintains a moratorium on all trades.

Last April, the U.S. Supreme Court issued a decision that may well dictate how tough the Navy's policy can be. After reviewing a complex legal battle between salvors and the state of California over the ownership of the *Brother Jonathan*, a steamer that went down in the 1850s off the California coast, the court ruled unanimously that, in effect, property not in actual possession of the owner cannot be protected by sovereign immunity. "The decision means that warbirds that aren't in actual possession of the Navy can be legitimately subject to a salvage claim," says salvor attorney Peter Hess, "and if they still belong to the Navy, then the Navy is obligated to pay a salvage reward."

In future legal battles, the Navy, of course, may interpret the decision differently. But salvors aren't wasting any time. "I'm going to go ahead and protect my investment," says Doug Champlin of the TBD. "I'm going to go get it before someone else does and we'll see what happens."

# Walk This Way

## Watching a geologist make his moves on Earth helps NASA design a suit for Mars.

by David S.F. Portree *Photographs by Raechel Marie Running*

The chill wind at northern Arizona's Meteor Crater has 40 miles of runway to build up speed. It scrapes up a cargo of dust as it races north over the flat desert, then smashes against the crater's south rim and throws the dust everywhere.

Geologist Dean Eppler doesn't mind the dusty wind—he's cozily sealed inside a spacesuit. With a hard torso and fabric arms and legs, the white spacesuit is marked with black fabric motion analysis targets. Eppler is wearing it to find out what features are necessary to allow a field geologist to—as he puts it—"do geologist stuff." Eventually, of course, the field the geologist will be exploring won't be in Arizona. It will be on Mars.

Last May, Eppler and a team of 10 NASA co-workers assembled at the rim of the crater, near Flagstaff, Arizona, to collect data for spacesuit designers. The site was the last stop in a two-week series of field tests held on a variety of terrain in the Flagstaff area. The NASA team chose 20,000-year-old Meteor Crater because it resembles many craters on the moon and Mars. Eppler, who estimates he has spent two and a half years of his career living and working on site, including three months in Mars-like Antarctica, was charged with judging whether the mobility joints and other systems of the suit—called the Mark III—are up to the task.

Perhaps in a decade or two, someone with Eppler's qualifications could be among the first humans stepping onto the surface of Mars. Understanding Martian geology is a prerequisite for other studies of the Red Planet. Paleobiologists seeking Martian fossils, for example, need to find out from the geologists whether Mars had lakes or bubbling hot springs, and if so, where. In addition, geologists will seek resources future settlers can use. It's going to be tough enough for Earthlings, after a six-month flight, to make sense of what they find on Mars. They certainly don't want their spacesuits getting in the way.

*On a test walk near Arizona's Meteor Crater, geologist Dean Eppler uses an ice pick to help support the Mark III's considerable weight (left). The excursion begins with suiting up: The suit's lower half is hung on a stand (below), the upper half is connected, and Eppler climbs in through the back.*

With his black Plexiglas visor down to screen out the desert sun, Eppler is safe from almost anything northern Arizona can throw at him. But the Mark III's protection comes at a price—the 175-pound geologist lugs around 212 pounds of suit and self-contained life support backpack. It makes him more fatigued and clumsy than he'd be on Mars, which has only one-third of Earth's gravity.

Flanked by engineers Wendell Smith and Frank Hernandez, who act as spotters, Eppler stops to do a site description. "We're standing in front of an outcrop of fairly shattered rock—I'm not sure if it's Coconino sandstone—from the shockwave associated with the excavation of the crater," he says. Smith helps Eppler position his geologist's hammer in his awkward, gloved hands. He whacks the outcrop until a piece comes off, then gingerly retrieves it from the ground with a scoop. Apart from the clumsy gloves, the suit allows him to use the hammer normally.

Ali Kakavand and Carlos Washington are charged with videotaping a selection of the tasks Eppler performs. They use four poles with colored targets at different heights to define a cube of space around the geologist. Back in Houston they'll use film shot from two cameras to create a three-dimensional digitization of movement possible in the Mark III. Usually such research is conducted in the lab, where environmental conditions can be carefully controlled, Kakavand explains. "Here, the sun is one minute behind a cloud, the next minute, comes out. That will play havoc with the computer program." He sighs. "We are trying to do the best we can with these difficulties. I don't know of anybody else who does this in the field."

The spacesuit, which turns 10 this year, is not the optimal experimental platform either. It was never intended for planetary use. Initially assembled by the Delaware-based company ILC Dover and modified extensively at NASA's Johnson Space Center in Houston, the garment started life as a $1.7 million advanced spacesuit for use aboard the space station back when it was a Russian-less program called Freedom.

Joe Kosmo, the test supervisor and NASA's most experienced spacesuit designer, intended the suit for weightless spacewalks in Earth orbit, not for nimble strolls up a crater rim in Earth gravity. The plan was to allow an astronaut to step outside the station to make repairs at a moment's notice. Going outside was to have been no more complex and time-consuming than donning a snowsuit in Antarctica. To permit that, the suit had to provide the spacewalker with the same air pressure as the station's interior, equivalent to that at sea level on Earth. It needed strong, hard parts that could contain that pressure; the extra weight they contributed would not be a problem in the weightlessness of space.

Continuing demands to keep space station costs down, however, led NASA to instead designate the suit currently making shuttle flights, the shuttle EMU, or extravehicular mobility unit, for space station use. Unwilling to see the Mark III go on the scrap heap, Kosmo's group at Johnson adopted the orphaned suit to test gloves, joints, and life support machinery needed for planetary surface operations. "It's a technology demonstrator, not a Mars suit. I want to stress that," Kosmo says.

In his 60s now and nearing retirement, Kosmo hopes the spacesuit tests will help form a bridge of experience between Apollo and the future. In 1962 Kosmo worked on the design of an early Apollo suit and demonstrated it for

President Kennedy. "The president came in, took off his coat, rolled up his sleeves, just like a regular guy," he says. "I was in the suit, and my division chief went through his presentation. He'd throw a quarter down on the floor to show how mobile the suit was. Well, the suit was mobile if you forced it. And I thought to myself, *I better damn well pick up this quarter!* I handed Kennedy the quarter. He had a big smile."

There's no president on hand today—in fact, the team jokingly calls the test a "covert operation." In January word came from NASA headquarters that all work aimed at sending people to the moon and Mars, including this field exercise, was cancelled in favor of programs directly benefitting the international space station. It came as both a relief and a surprise, therefore, when Kosmo's team was granted the $20,000 it needed to do the test just a month before the group was scheduled to head to Arizona.

The exercise is the suit's first trip out of Houston. The Mark III has flown, however, and has experienced something very like Mars gravity. Among other tests, the spacesuit last year took a ride aboard the modified KC-135 transport NASA uses to create brief periods of weightlessness or reduced gravity. One of the objects of the test was to compare the mobility of the Mark III with that of the old Apollo moon suit, and, as ill-suited to planetary surface

*Eppler and test supervisor Joe Kosmo confer near the crater (above)—a site chosen for its resemblance to terrain on the moon and Mars. As the geologist performs typical fieldwork (top), a motion analysis team videotapes his movements.*

work as the Mark III is, it easily won the competition.

Subjects in both the Mark III and Apollo suits started out the test on their backs, as if they'd fallen, and tried to get up in simulated Martian gravity. The individual wearing the Mark III got up right away; when the Apollo-suited subject struggled like a beetle on its back, Mark III went over and helped him up. In his office in Houston, Kosmo displays pictures of the test subject in the Mark III doing a handstand aboard the KC-135. "We've made some progress since Apollo," he says proudly.

Eppler's teammates wouldn't mind wearing the Mark III just now, even if it does weigh 212 pounds. Hands go to hats as a powerful gust rattles the cameras on their tripods and shreds the pink flags marking Eppler's 426-foot ascent up the crater rim.

"What was that climb, Dean?" Kosmo asks, after Eppler has crested a little slope. He's after the geologist's subjective rating of difficulty. "About a 'B,' " Eppler reports. Jenny Glassley, the communications technician, grimaces as wind noise picked up by the team's headset microphones obliterates Eppler's estimate, forcing him to repeat it. The 20-year-old Purdue University student brushes at dust accumulating on her equipment while Kosmo pencils a "B" on his clipboard.

Eppler nears the end of his traverse. "Oops," he says over the wind roaring on the radio. "No cooling."

"Get him out of there," Kosmo orders. "Back to the suit stand, Dean."

Cyle Sprick, a technician from Oceaneering Space Systems, the company that manufactured the suit's life support backpack, explains the unit's malfunction. Designed to allow only testing of the suit and not intended for spaceflight, it is a single system that provides both cooling and air. Cool water flows through tiny tubes in the long johns Eppler wears, transporting the heat he generates to a tank of supercold liquid air. The water vaporizes some of the liquid air for him to breathe as it circulates past the tank. The liquid air, in turn, recools the water. If the backpack cools too well, though, as happened here, the water freezes, damming the flow. "A more mature design would monitor the water temperature and metabolic rate to avoid freeze-ups," Sprick says.

With aid from Smith and Hernandez, Eppler backs into the suit stand and locks on. Sprick and Willy Warson, the suit tech, pry open the backpack hatch and Eppler wriggles out, his face covered with sweat after just five minutes without cooling.

As he slips an orange flightsuit and boots over his long johns, Eppler kicks up more of the ever-present dust, exclaiming, "500 days of this? Ugh!"—a reference to the probable duration of a stay on Mars by astronauts. The Apollo moonwalkers had to contend with abrasive moon dust during their two-day lunar visits. It scratched dials so badly they couldn't be read and jammed

*Attempting to examine a rock, Eppler discovers the helmet's bulging visor doesn't allow him to use a field glass properly. Such observations will assist in the design of suits intended for strolling some day on a far more distant patch of desert.*

locking mechanisms in the astronauts' suits. Mars dust could be worse—it floats in the air and thus will infiltrate equipment even if astronauts manage not to kick it up. This is a problem for some future spacesuit designer at some future test. The Mark III doesn't take dust infiltration into account: Sprick, Warson, and the others just take the suit apart every couple of days and spend several hours cleaning it.

While the backpack is thawing, Kosmo drives to the Meteor Crater visitor's center to buy sandwiches. Meanwhile, members of the motion analysis team prepare for Eppler's next excursion.

The wind gets stronger. As Kosmo arrives with lunch, a towering red dust devil, looking ferocious and Martian, sweeps across the crater and toward the group. "Get the cameras!" Hernandez shouts. The dust devil veers to the east and blows apart on the crater rim, firing off a gust that flaps the Mark III's arms. One of the black motion analysis targets takes flight.

After thawing for about two hours the backpack is ready for use. Smith, Hernandez, Warson, and Sprick position themselves around the Mark III. Eppler squeezes inside, out of the wind. But he immediately encounters an un-Mars-like problem: There's an insect inside the helmet.

"I found that it's very hard to ignore even a very small bug when the only place he can fly is within an inch of your face," he says later. "Unless you can figure out where it is and hit it with the side of your head, you can't even smash it because your hands aren't in there."

The alien hitchhiker is freed, the suit re-sealed, and Eppler released from the suit rack. He sets up mockup instruments inside the motion analysis cube. The hollow, undetailed mockups resemble instruments the Apollo astronauts used, including a magnetometer and seismometer, but are lightly weighted to simulate how they would feel on the surface of Mars.

Kosmo is quick to remind me, though, as he has several times throughout the test, that NASA currently has no program to put astronauts on Mars. Indeed, upon returning to Johnson Space Center the team learned that they were prohibited from doing any further fieldwork until the space station is completed, around 2003. This included tests scheduled to begin this fall on two mostly soft prototype planetary suits. I caught up with Kosmo shortly after he got the bad news. "We're going to need to do this work sooner or later," he said, more resigned than unhappy.

A manager in charge of advanced suit development told me that his office had let the Flagstaff tests go ahead for reasons of morale—that is, to keep alive the spirit of exploration despite repeated space station delays. Lacking the cachet of a formal program, progress toward Mars throughout NASA is measured in disconnected projects, long pauses, and sideways stumbles.

Back at the crater, the wind gusts strongly enough now that Eppler staggers slightly as he starts his second climb up the rim. But Eppler, the Mark III, Kosmo, and their small entourage continue their struggle. They crest the slope and move out of sight behind a boulder. ✈

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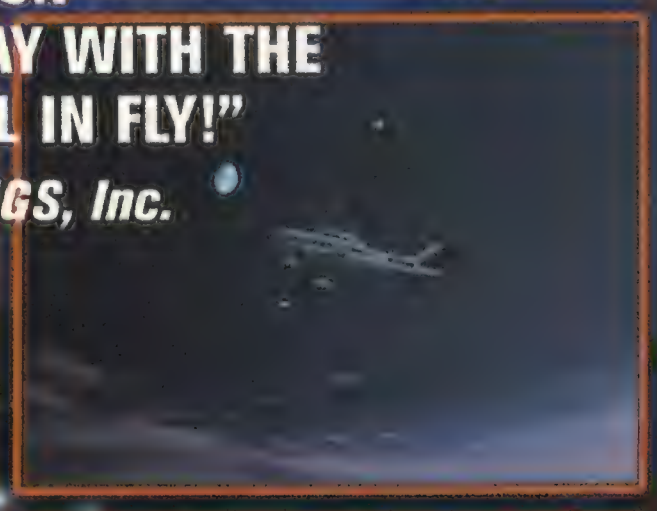

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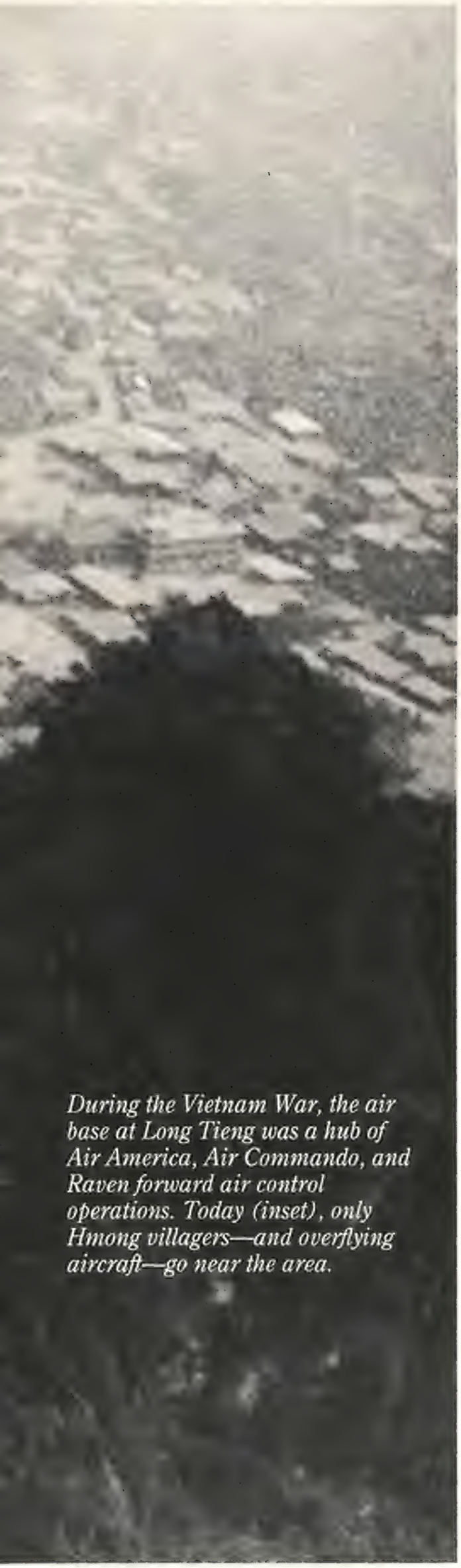


*During the Vietnam War, the air base at Long Tieng was a hub of Air America, Air Commando, and Raven forward air control operations. Today (inset), only Hmong villagers—and overflying aircraft—go near the area.*

ALL B & W PHOTOS: UNIVERSITY OF TEXAS–DALLAS HISTORY OF AVIATION COLLECTION

# THE RAVENS OF LONG TIENG

*In the remote highlands of Laos, U.S. Air Force pilots fought a secret war.*

It all shows in the grainy photograph—the short landing strip, the limestone karst jutting up at one end, the mountains and ridges rimming the base, and the shacks and buildings scattered along both sides of the runway. One of those shacks is the hooch where the forward air controllers known as Ravens drank every night. One is the home and headquarters of the Laotian Hmong leader, General Vang Pao. Another is the CIA operations shack that burned in 1971 when a U.S. Air Force F-4D dropped cluster bombs on the base by mistake.

During my first tour, I was at Ubon, Thailand, flying combat missions in F-4 Phantoms. From August 1966 to February 1967, I must have flown over the base at Long Tieng a hundred times without ever seeing it. Long Tieng is in the north central highlands of Laos, a remote, ominous territory, where the tribal Hmong scrape a living from the steep slopes and jungle ravines. A tiny settlement, it became, in the 1970s, the mountain stronghold of the Hmong, their CIA bosses, and the Ravens. Nowadays, the CIA and the Ravens are long gone, but the Hmong are still there.

VIETNAM MEMOIR

by Ralph Wetterhahn

During the Vietnam War, operations in Laos were a rumor, a legend. For us, the country was a bomb dump, a place to go when the weather was too bad for attacks over North Vietnam. Soon, however, word began to filter out to pilots in Vietnam and Thailand that there was "another theater," one where there was no higher echelon, no rank, and few rules. We heard about other pilots flying Cessna O-1s and North American T-28s out of places with exotic names like Luang Prabang, Xieng Khouang, Pakse, and Long Tieng. Fighter pilots are by nature independent and aggressive, and those mysterious bases had an allure for those who liked the idea of fighting a high-risk, no-bullshit war.

As my first tour was finishing, the war in Laos—and Long Tieng's role in it—began to mushroom. By the time I flew overhead again in 1970, flying A-7 Corsairs while on exchange duty with the Navy, the base was running full bore and 40,000 people lived there. Our missions in the A-7 were to interdict roads, bridges, and truck parks in an attempt to stop the flow of men and arms coming down the Ho

Chi Minh Trail, which snaked through Laos and Cambodia and into South Vietnam. We'd launch from the USS *America*, fly across South Vietnam, then enter Laos and contact the Ravens, who, while flying circles in slow O-1 Bird Dogs, would mark our targets with smoke from white phosphorous rockets. We would roll in and unleash our stick of 500- or 1,000-pound bombs, then watch as the O-1 dipped low to check our accuracy. After the pilot radioed his report, the O-1 would vanish into the gray-green backdrop of Laos, toward a rugged area of craggy peaks and deep valleys.

Even after two combat tours in Vietnam and a year flying from Thailand, I've never seen the base they returned to. I tried this year, but was prevented by the Lao government—members of a tour group had been ambushed recently, some of them murdered, and there had been reports of isolated fire fights in the vicinity between the Hmong and government forces.

My wife Carol, who had assisted Laotian refugees settling in the United States, eventually introduced me to Gayle Morrison, a historian who has studied the Hmong since 1977. The secret, ramshackle base is there in Morrison's collection of photographs, proof—to me, anyway—that the hair-raising combat accounts and often touching stories I've heard about Long Tieng really happened.

The war in Laos was the biggest clandestine operation ever run by the CIA. Most Americans first began to hear about Laos in 1961, at a time when that country's neighbor to the east, Vietnam, was equally unknown. U.S. aid had been flowing into Laos since 1954, the year French forces fell at Dien Bien Phu. That defeat resulted in the Geneva accord that divided Vietnam, giving all territory above the 17th parallel to the communist Viet Minh. One intent of the settlement was to assure that Laos, at the time ruled by a king whose bloodline was centuries old, remained an independent country. But the Laotian border with North Vietnam, the scene of conflict for centuries, continued to prove porous to incursions and influence. Communist-aligned Pathet Lao guerrillas within Laos became even more emboldened by the victory of their longtime Viet Minh sponsors across the border in North Vietnam.

Much of the U.S. aid money infusing the Royalist government was siphoned off by corrupt military officials. Angered by this graft, a relatively low-level officer in the army, Kong Le—a paratroop battalion commander—staged a coup and took over the capital city, Vientiane. Within days, Laos became a fragile coalition of murky allegiances and factions. The Pathet Lao took advantage of the confusion and expanded their influence and territory, and North Vietnamese operatives infiltrated the loose government Kong Le had cobbled together. Military analysts in the Pentagon openly discussed an invasion to restore stability to the small nation, which now threatened to become a cold war flashpoint—the Pathet Lao and Viet Minh were supported heavily by the Soviet Union. However, over the next year, during which an ongoing Geneva conference attempted to restore peace in Laos, and the Bay of Pigs invasion in Cuba ended disastrously, the focus began to shift to Vietnam, which, to U.S. strategists, had become the more logical place to mount resistance to com-

munist expansion in southeast Asia. In November 1961, U.S. advisors and troops were sent to South Vietnam, shortly after a formal agreement was reached in Geneva designed to keep Laos neutral. By October 1962, all U.S. and Soviet advisors and troops had left Laos—except for those who went underground.

Covert operations in Laos included the CIA's Air America helicopter and fixed-wing cargo programs, and came to include a new initiative that was named the Steve Canyon Program, after the legendary comic strip aviator. Steve Canyon began at the behest of the U.S. ambassador to Laos, William Sullivan, who wanted to hold off the North Vietnamese army as it continued to develop the Ho Chi Minh Trail. Pilots selected for the assignment—who would soon get the radio callsign Ravens—were to be excellent forward air controllers, or FACs, with combat experience. The first of these were two clean-cut and eager Air Force fliers stationed at Nakhom Phanom (NKP) Air Base in Thailand but assigned to temporary duty at Khe Sahn in South Vietnam. First Lieutenants Jim F. Lemon and Truman "T.R." Young flew O-1 Bird Dogs along the demilitarized zone between South and North Vietnam, providing forward air control for strikes by fast-moving jets. They also flew missions inserting and extracting U.S. special forces teams into Laos. Operating mostly on their own, they led a maverick existence during the day and a reveler's at night.

For Lemon and Young, the new assignment began when their commander called them into his office after they returned to NKP in 1967. "He started by congratulating us on the good results we'd obtained at Khe Sahn and telling us the report from the major at Khe Sahn about our rat-racing [unauthorized acrobatics] in the Bird Dog would not be included in our records," says Lemon, who today works for the defense contractor Raytheon. "Also, the business about the broken furniture during our homecoming party wouldn't leave NKP. He said all that hadn't bothered him because he liked our spirit."

After 20 minutes of flattery, the commander began to describe a unique posting. "It was a FAC assignment—he'd already convinced us we were the two best FACs in the Air Force—but the rest of it was mysterious," Lemon says. "We'd be operating special airplanes and working a separate and very important part of the war. Most intriguing, we'd be the experts. We'd run our own show. All we had to do was volunteer. There was no question about it—we were eager volunteers."

Soon, the two pilots were riding in a C-123 transport over the Mekong River to Vientiane. Young and Lemon, as well-trained and experienced FACs, brought an expertise missing at Long Tieng. Air Commando pilots, U.S. Air Force holdovers from other CIA covert operations in Southeast Asia, flew Pilatus Porters and used hand-dropped smoke grenades to mark targets, attempting to thwart the movement of supplies on the trail. But "as any FAC would know," Lemon says, "without smoke rockets, they were having trouble getting the mark down without taking a lot of hits." Lemon and Young

GEOFFREY CLIFFORD

*The CIA gave Hmong leader General Vang Pao (opposite, pictured with an agency advisor) weapons and money. Air Commandos—then the covert arm of the U.S. Air Force—and Ravens flew a variety of aircraft, including the Pilatus Porter (above), as they directed air strikes. Many battles took place among the prehistoric stone urns of the Plain of Jars (right).*

were expected to change all that. The Air Commandos provided the necessary link between air and ground operations. "There was a need to somehow mesh the U.S. Air Force, with its supersonic jets, with these Iron Age tribesmen on the ground," says Roger Warner, an author who has studied Laos and the CIA's involvement there. "The way to do it was through the Air Commandos, who had a long-standing connection to the CIA in Laos and elsewhere, so there was a need that became very apparent—How do you get everyone working together? The Ravens were absolutely...a subset of the Air Commandos."

The Ravens usually had tours of six months to a year, but the Hmong were in for the long haul. The CIA had been operating in Laos since the early 1960s, quietly arming, training, and advising the upland hill tribes in their fight against the Pathet Lao. The Hmong and the lowland Lao are ancient rivals, and because the lowlanders were largely aligned with the Pathet Lao, who were helping North Vietnam maintain the Ho Chi Minh Trail, it was the Hmong that the CIA courted. The Hmong are a slash-and-burn society, raising pigs, growing rice and poppies, and selling the latter's extract as the raw material for opium and heroin. Like frontiersmen, the Hmong are always armed. The Hmong were facing increasing threats not only from the Pathet Lao but also from the North Vietnamese, who were both gaining territory in the Plain of Jars, a vast and tactically important area to the north that over the centuries had been the scene of countless battles between Laos and Vietnam.

When Lemon and Young arrived, they put on jeans, T-shirts, and bush or cowboy hats, and turned in their I.D. cards. As far as the Air Force was concerned, they vanished from official existence. The FACs used a network of bases in the mountains called Lima Sites, many of which were remote and harsh outposts set up by the CIA.

*Royal Laotian pilots and some Ravens flew North American T-28s (below) against the Pathet Lao and North Vietnamese. On some of their first FAC missions, the Ravens flew the resilient short-takeoff-and-landing Helio Courier (bottom).*

WARREN THOMPSON

"Long Tieng was an almost uninhabited valley when the CIA established it as a headquarters for [Hmong leader] Vang Pao in 1962," Warner says.

Despite its starkness, Lemon and Young found Long Tieng well prepared for military operations, a legacy of the Air Commando and CIA operations already under way there. The pilots' most pressing needs were to get acquainted with their new aircraft, which included the U-17, a military version of the Cessna 185 taildragger. Also on hand was the short-takeoff-and-landing Helio Courier, which the Air Force had operated since the late 1950s. Ravens would eventually fly the O-1 and the T-28 in their tenure at Long Tieng. In Vietnam, the widely used O-1 was followed by the pusher-puller Cessna O-2 and the high-performance North American OV-10 Bronco, designed specifically as a counter-insurgency/FAC platform. Despite the arrival of newer aircraft in Vietnam, the O-1 would remain the staple in Laos.

Lemon and Young began to prepare for operating as FACs in a new location, although their preparation was improvised. "My checkout in the U-17 was the flight up to Long Tieng, also referred to as 'Lima Site 20 Alternate' or 'Alternate,' " Lemon says. The U-17 was almost new, with only 400 hours on it. Eight rocket tubes were mounted on the wings, and inside was a backpack radio tied into an antenna on the top of the fuselage that let the pilot talk to the fighters. The U-17 was gray with no markings. "It had metal braces to hold the insignia on the side of the fuselage and a packet of metal flags so I could be part of any air force I wanted," recalls Lemon. Ravens communicated with Cricket, a C-130 command post that would direct fighters in the area to targets the Ravens marked.

After a quick orientation flight, Lemon's checkout pilot left for Vientiane. Lemon found himself "alone in the Raven hooch, a new guy in a very strange world." The

*As the war progressed, Long Tieng expanded from a few aluminum shacks to a bustling center for thousands of villagers, soldiers, and American advisors (above). Overnight accommodations for visitors were little more than a dirty cot and a rifle (right). The base is off-limits today, but some reminders of the war in Laos remain in more open view (below).*

GEOFFREY CLIFFORD

terrain was unlike anything he had seen in Vietnam. "At the north end, a ridge rose some 300 feet. We called that the 'vertical speedbrake' for obvious reasons," says former Raven Charles W. "Buddha" Hines. "Karst formations rose on the right at the south end, making approaches a hair-raising event, especially when the weather was bad."

The day Lemon arrived, he met the legendary General Vang Pao. At five foot five, he was tall for a Hmong. A small wart was the only distinguishing mark on his round, intense face. Vang Pao had fought with distinction alongside the French, and was lauded for his displays of leadership. He had been educated in the early 1950s at the French Police Academy in nearby Luang Prabang. Of 80 students, Vang Pao was the only Hmong. Treated badly by the lowlanders, Vang Pao got his revenge, graduating first in his class. Back among the high country tribes, Vang Pao became their Napoleon.

Vang Pao gave Lemon the first of his assignments. The enemy had been spotted cutting a road through heavy forest toward the general's outposts. The work on the road had to be stopped.

"Over the next two days, I flew five missions over that road with Thuy, a lieutenant in the Thai air force who spoke Lao," Lemon recalls. "Working under low cloud cover, using Lao T-28s, American A-1s [Skyraiders], and [U.S.] T-28 Trojans from NKP we killed three trucks and a bulldozer."

Vang Pao was quick to laud Lemon's performance on the missions. "I received a prize at dinner, a pig's ear, an honor Vang Pao reserved for the soldier who had turned in the day's best performance. I tried to be gracious, but chewing the gristly pig's ear wasn't much motivation as far as I was concerned."

This war was more intimate than the one pilots were accustomed to in Vietnam, with its bureaucratic rules. Both living with, and fighting alongside, the Hmong proved gratifying to many of

GEOFFREY CLIFFORD (2)

the Ravens. "I think all of us very quickly developed sympathy with these people and threw a little bit more of ourselves into the war than what we were seeing perhaps in South Vietnam," Lemon says. "It only took you about a month or two to realize that this was an extraordinary mission."

The Ravens flew with Hmong observers, called backseaters, who provided the vital link with tribal ground forces operating under thick layers of jungle canopy. "You wanted to be very certain you understood precisely where the good guys and precisely where the bad guys were, particularly when the friendlies were under attack," Lemon says. "Once the [backseater] understood where he wanted the bombs, the next half of the job was conveying that to the fighter pilots who were going to drop the bombs—you did that with smoke rockets and language: 'You see the bend in the river? We want you [to drop] 200 meters directly west.... Now watch my smoke.' "

Vang Pao himself flew several early flights with Lemon. Then on one mission their aircraft got shot up by small arms fire, and the CIA boss known simply as John decided Vang Pao was too valuable to risk flying more FAC sorties.

Lemon and his fellow Ravens also flew from other Lima Sites, especially LS-36, some 50 miles to the north of Long Tieng. Lemon flew frequently with Hmong Major U Va Lee. "His nickname was 'the Indian' because he looked more like a native of North America than an Asian," Lemon says. "He had one word of English, 'enemies,' and I only had a few words of French, Lao, and Hmong, but it was enough to get the job done."

Increasingly, the Ravens began to embrace the outrageous style they were becoming famous for, especially after a visiting Air Force general disgustedly branded them "Mexican banditos."

Wearing a decidedly unmilitary mustache, a Bowie knife on one leg, and a gold bar strapped to the other (to buy

*The Hmong (top) live much as they always have, raising cattle and growing crops, including opium (center). A United Nations initiative now encourages them to grow other cash crops. Raven aircraft, like the T-28 at right, often had to fly through the haze created when villagers burned the ground in preparation for the next growing season.*

his way out of trouble), Fred Platt epitomized the type of pilot who signed up to be a Raven. He quickly gained a reputation among the Lao backseaters for his extraordinary daring. One of them, Vang Chieu, got his hand shot off flying with Platt. Another Platt backseater got his leg shattered by a round that came through the airplane's floorboard.

Platt would eventually crash 11 airplanes. He earned the nickname "Magnet Ass" for the amount of gunfire he attracted. When it came to accompanying Platt, "No fly, no die" became an unwritten motto among the Hmong. When the backseaters refused to go with him, Platt got approval to fly alone. But Platt liked company, so he began taking along a tame bear cub and at other times a pet anteater. "The anteater would just wrap himself around my arm as I flew," Platt says. "The bear sat wherever he wanted."

Some missions required human companions, however, and Platt sometimes had to search for a Hmong backseater to fly with. "They were just scared to death," former Raven Mike Cavanaugh remembers. "The backseaters hid behind the couch in their hooch when they saw Platt coming." Once Platt grabbed the couch and turned it over. "Two of them were hiding there," Platt says. "I hauled one of those guys out to go fly."

With a brand-new backseater, Platt found a cache of oil drums. Instead of waiting for fighters, he began shooting his marking rockets into them. Tracers streamed up from a 12.7-mm antiaircraft gun. The airplane shuddered. Oil began to spew from the cowling. "Heavy fire, black smoke—shutting down the engine now," Platt radioed to Cricket. Platt flew toward a karst ridge, barely making it as an updraft lifted his O-1 at the last moment. In front of him was a wide valley with dikes and paddies. As he flared to land in a paddy, Platt noticed camouflage ahead, covering a sunken road that crossed his path. He tried to zoom over the depression but the airplane stalled, and its underbelly hit the far lip. Platt's harness snapped. He was hurled forward into a cockpit crossbar while his knees smashed into the instrument panel. The prop dug in, flipping the plane on its back. The two men hung upside down. When Platt came to, he unstrapped and fell onto a bed of broken plexiglass. Then he released the harness of his dazed backseater. The man fell on his head and began to moan.

*A Cessna O-1 Bird Dog undergoes maintenance at Udorn, Thailand. Many Ravens had flown O-1s during FAC missions in Vietnam.*

Platt saw Pathet Lao troops coming over a hill, a half-mile away. When his backseater refused to move, Platt slung him over his shoulder and carried him, along with a machine gun, radio, map case, M-79 grenade launcher, and a bandolier of shells, as he dashed behind an earthen bank nearby.

While a full-scale search-and-rescue operation was being organized, Dave Anckleberg, the pilot of an Air America helicopter, heard what was going on and rushed to the scene. Platt had been on the ground for 30 minutes using his grenade launcher to keep the enemy at bay when he heard rotors. He saw Anckleberg's chopper settling down just behind his position. Platt dragged the backseater to the helo, giving him a boost into the cargo bay, then hopped aboard with some help from the crew chief.

Platt's nose was broken, his knees were badly bruised, and he had a spinal compression and a broken neck with seven hairline fractures. Back at Long Tieng that same night, he partied hard, then woke the next morning paralyzed. Raven Mike Byers folded Platt into the back seat of an O-1 and flew him to Udorn Air Base in Thailand. Thus began years of slow recuperation to regain the use of his arms and legs. To this day, he walks gingerly and is never without pain. His Lao backseater never flew again, preferring to return to the infantry.

By March 1969, another backseater, Moua Fong, had flown hundreds of missions with both Ravens and Lao T-28 pilots. While over the target area one day, the O-1 he was riding in came under heavy attack from ground fire. "The plane got shot through many times," he recalls. "I took a round in the right leg, below the knee." The pilot trimmed the plane, then helped stem the loss of blood. The O-1 began leaking fuel and the plane turned toward Sam Thong, Laos. On final approach, the engine quit. "The pilot dead-sticked the plane to a hard landing, and I was taken to the hospital."

Mike Cavanaugh flew with a favorite backseater the pilots named Scar, a second lieutenant about fifty years old. "He was very good on the radio. Scar would talk something like this: 'Many, many enemy to the north, many, many enemy to the south.' He wouldn't show you on a map; he would point. I couldn't see a damn thing; I knew he couldn't either, but he was convinced the enemy was

*As the Pathet Lao advanced, not even Long Tieng's secrecy kept it protected from shelling (left). The Ravens and a few Hmong left in a hasty 1975 evacuation. Though the Hmong fought on, they were defeated and suffered more than a decade of persecution.*

there. I got to [where I] believed Scar. Many times he hit the jackpot and we did kill 'many, many enemy.' "

As each rainy season cleared, the Pathet Lao gained strength. Between 1967 and 1973, the United States became more willing to attack Laos in a decidedly uncovert manner, including B-52 raids. The amount of ordnance dropped on Laos surpassed the tonnage the Allies dropped in Europe during World War II. Conventional bombs equivalent to the destructive power of 20 Hiroshima-type weapons fell on tiny Laos each year. And still the North Vietnamese and Pathet Lao poured south.

Raven John Wisniewski arrived in Long Tieng in late 1971. On his first flight in Laos he was struck by the rugged beauty of the mountains. As his O-1 approached the fabled Plain of Jars, he expected a breathtaking view. Instead, he came upon a moonscape. "Everything was bombed out," he says. "Everything was worked over with bombs."

The North Vietnamese and Pathet Lao continued to advance, and by late 1972 the Ravens were directing air support for three separate areas in the Laotian panhandle alone, not to mention for the continuing fight in the north, in the Plain of Jars, and all along the Ho Chi Minh Trail.

Hal Mischler, who was finishing his tour and had already shipped his effects home, was moved to Pakse in the south. A massive air campaign had begun against North Vietnam—Nixon's Christmas bombing—so no fighter-bombers were available for Laos.

On the morning of December 23, the town of Saravane near Pakse was un-

der siege. Mischler took to the air in an O-1 with a backseater to help defend the town by himself. He dipped low trying to draw ground fire to locate the enemy position—"trolling for guns," as the ground commander would describe it later—when the O-1 was hit by flak. Flames licked their way into the cockpit. The backseater escaped the inferno by jumping from the plane, only to be cut in half on a brick wall. Mischler rode the plane in. His body was recovered by the friendlies at Saravane and flown back to Pakse. The next day, an A-7 clipped a wing strut on a Raven O-1. The pilot, Paul V. "Skip" Jackson, spun to his death, becoming the last Raven to make the supreme sacrifice.

On January 27, 1973, the Paris Agreement on Vietnam was signed. U.S. military involvement in North and South Vietnam ceased. The prisoners of war started coming home, but the fighting in Laos didn't stop. The last outpost defending Long Tieng fell on February 22, 1975. An impromptu evacuation was masterminded by General Heinie Aderholt, who arranged for a motley fleet of aircraft including a C-130, C-46, and Pilatus Porter. He sent a helicopter to retrieve Vang Pao. Long Tieng was mobbed by villagers trying to get out—only a lucky few would leave. It would take two more years before all Hmong resistance would collapse.

That collapse was devastating to the Hmong—tens of thousands were killed by the communists during the next 10 years, and today, the Hmong who survived are on the bottom economic rung of a profoundly impoverished country. Many Hmong fled to refugee camps in Thailand. Many of those were eventually repatriated against their will, and others disappeared into Thailand as illegal immigrants. Some of the Hmong who escaped Laos came to the United States, but only a handful of backseaters who flew with the Ravens survived. One of them, Moua Fong, lives in Orange County, California. After the fall of Laos in 1975, he travelled on foot from Long Tieng through enemy lines, then swam the Mekong and spent four years in a Thai refugee camp.

The Hmong leader, Vang Pao, escaped and lives in exile in California. He still vows to return. The surviving Ravens meet for a yearly reunion at a hotel outside Randolph Air Force Base in Texas.

Laos today is a mix of old struggles and new economic trends. At the Xieng Khouang airbase there are eight MiG-21s stationed now instead of O-1s, but neither collectives nor state factories exist. Americans, and the economic development they bring, are welcomed in many parts of the country. Getting a business license in Laos takes two weeks—no hassle, no under-the-table payoff. In spite of economic setbacks in Asia, capitalism is slowly taking hold.

Long Tieng appears to be largely cut off from the changing economy. It remains forbidden and remote, strictly off-limits, and visible only from the air. "When I flew over Long Tieng, my breath just stopped—I didn't think I'd ever get to see it," says Gayle Morrison, who is writing a book about the hasty 1975 evacuation. "The airstrip is still there...although you have to know exactly what you're looking for. You have to know the ridgeline, what side of the plane to sit on...otherwise you wouldn't have any idea. There's a small settlement there but it's hard to tell if it's a military outpost or if it's a small village. The buildings in the CIA compound are still there.... Because [seeing the base] was the culmination of 10 years of oral history on Long Tieng, I could look down and pick out exactly which buildings still stood and which didn't, being pretty confident about what I was seeing."

There are two daily flights over Long Tieng. "In between, the airspace is wide open, and nobody's watching [Long Tieng]," Morrison says. The only access to the village itself is by a single road.

"Some buildings [at Long Tieng] are being used, but some buildings were destroyed long ago," says Mai Sayavongs of the Washington, D.C. Embassy of the Lao People's Democratic Republic. "It no longer exists as a military base." Today, the area around Long Tieng is at the center of a United Nations-sponsored program aimed at assisting the Hmong to grow crops besides opium, Sayavongs says.

"[Information about Long Tieng] was forbidden so long to the international press, the U.S. [citizens] didn't know about it, Congress only sort of had a clue, it was denied in every possible way by the U.S. side," Morrison says, "And now there's not a war going on, but [Long Tieng] is still continuing in a weird and strange way." More than 20 years after the last American left, the former mountain stronghold of Vang Pao and the Hmong has lost none of its mystery.

GEOFFREY CLIFFORD

*Sculptures in Laos protest the thousands of tons of bombs dropped on the country, but Americans are still largely welcome there today.*

# WHAT I LEARNED AT KITPLANE CAMP

## There's a lot to think about while the glue dries.

by Phil Scott

*Illustrations by David Povilaitis*


I don't think I'm going to like it here. Already no one likes me. What if it's like the summer I had to go to fat camp and the other guys took turns putting Ben Gay in my underwear? And my crafts project looks really hard. In the next five days, we're supposed to build an entire ultralight airplane from a kit. We'll see....

**OSHKOSH, WISCONSIN; DAY 1**

Things go kind of slow the first day at the Experimental Aircraft Association's Adult Air Academy, a five-day course held at the EAA's home base in Oshkosh each February, when the weather is at its frostiest. In the morning we sit around tables in the big clean shop and eat cookies and slurp coffee while everyone stands up, briefly introduces themselves, and tells why they have come to camp. It takes forever.

There are 14 of us campers, about half of whom look like they'll soon have retirement time on their hands. All are thinking about building an airplane and want to learn the basics. Some, like Charles from Kentucky and quiet Jack from Alabama, actually have this particular kit at home (albeit unopened, awaiting the spark of inspiration they hope the camp will provide). John, a computer guy from California, went so far as to build the wing ribs before getting sidetracked by everyday life. He too is here for motivation. I tell you what, though, plunking down four grand for a pile of wood and aluminum pieces would be all the spurring this horse would need.

Surprisingly enough, at age 37 I'm not the baby of the bunch. Paul, a Canadian now living in North Carolina, is 35. He's been looking forward to camp, though he admits he was a bit apprehensive that he would be the youngest guy here. (Then again, Jack told me the same thing and he's edging 60.) And it's not all guys. There's Debbie, an airline pilot, who's here with her husband Jim, who also flies for the lines. We even have a den mother, Linda, who volunteers during the summer for the


regular EAA Air Academy, which caters to kids. Including her, there are 13 EAA volunteers—retired guys with airplane building experience. The easy way to tell us from them is that they wear belt buckles with airplanes on them: a Mooney, a B-29, the Wright *Flyer*. While Owen has the most airplane-related stuff on his belt, the one named Tom seems to be in charge.

The most important guy, however, is Mike Loehle, who donated the Loehle Sport Parasol kit that we'll be putting together. Designed by Mike to be inexpensive, simple to build, and easy to fly, the Parasol is a wood-frame, fabric-covered monoplane, its single wing set high in parasol fashion to allow excellent visibility and easy access for maintenance. With a wingspan of just under 26 feet and a length of just over 18 feet, the Parasol weighs in at a delicate 252 pounds. Depending on what size engine it gets—28- to 50-horsepower—the Parasol has a cruise speed of 60 to 70 mph. Right now, though, it's just a pile of hardware and unfinished wood of varying lengths and thicknesses.

Mike tells us that he started his business out of his dad's basement about 20 years ago; today his factory has 20,000 square feet set on 137 acres, including a grass landing strip. He's 38.

Mike hands out a two-page project list, which is essentially the battle plan for attacking the kit. We'll start off building the wing ribs and pieces of the tail from wood, move on to fashioning the

metal fittings that make up the landing gear, engine mount, and controls, and finish up with the wood skeletons of the fabric-covered fuselage and wing (which will be built in two halves, the right and the left). If we get all that done, we'll assemble the components, paint everything, then kick the tires and fly it away.

After getting the project list, everyone eyes one another sort of nervously and starts talking about glue. Mike says the stuff we're going to use to hold our airplane together is called T-88. It's a two-stage epoxy; you mix the stages in equal portions before slathering great gobs onto the pieces you want glued. Then you staple the pieces together with a construction-grade stapler, wait overnight for the joint to dry, and come back and pull the staples out. (Homebuilders used to hammer in tiny brass nails, but they found that staples work just as well.)

Following the initial formalities, we actually get into the shop, which has the comforting smell of power tools, wood, oily steel, and av-gas. The instructors introduce us to some of the equipment we'll be using. There are power tools like the band saw (for cutting curves and thin strips of wood), the drill press (for drilling holes in metal fittings), and the belt sander (which smooths parts and takes off excess material—but unfortunately can never add material). Then they show us some delightfully sinful shortcuts, like using tin snips (scissors-like implements for snipping sheet metal), hacksaws (for cutting thicker pieces of metal), and even good old paper scissors to cut thin pieces of wood. This is in direct but refreshing violation of that homily about using each tool for its specific purpose—or whatever it was my dad screamed at me that time he caught me hammering nails into concrete with his adjustable wrench.

All of the tools are simple, everyday workshop fixtures; none are mystical, sacred airplane-building devices that can't be mastered by folks with common sense and an itch to work with their hands. Still, the instructors urge us to try out the tools on scraps of wood and metal if we aren't familiar with them. Then they coax us into actually constructing the aircraft components depicted in the blueprints.

Somehow I team up with Mark, a Kentuckian with a sweet, squinty smile, and together we tin-snip and dry-assemble a wing rib on a pre-built jig. Once we have all the pieces snipped to our satisfaction (and Tom's), we mix up some T-88 and began gluing and stapling everything into place. The hardest part is getting a straight, thin strip of spruce to bend into the proper airfoil shape. We start where the rib meets with the solid plywood piece that forms the wing's rounded leading edge, then bend the spruce and slip a bit of it into the jig, then bend more and slip more, until finally the whole piece of spruce is held firmly by the jig. From there we glue and staple some 16 geodetic cross-braces to strengthen the top and bottom of the rib and set the whole works aside to dry.


While some campers build more ribs, others cut and glue pieces of the tail, and still others cut and drill hunks of aluminum with still-mysterious purposes. I move on and help cut and assemble the skeleton of a tail surface. And, with my considerable rib-building expertise confirmed, I lend a hand to Jack, who has begun building a rib on his own.

We started at 7:30 a.m., had coffee breaks morning and afternoon, an hour break for lunch, and knocked off for a catered dinner at 6 p.m. This will be the pattern for the week.

One other note: Wisconsin is the land of dairy products (Garrison Keillor once said that the state motto should be "Eat cheese or die"), but everyone uses Coffeemate. This makes me suspicious.

**DAY 2**

When we get into the shop this morning, Jack and I remove the staples from our rib and pop it from its jig. Much to our surprise, the front end sproings apart. We look at one another in embarrassment, then lay the rib down and silently walk away in different directions. A few minutes later, Tom tells us we probably didn't let the glue dry long enough before we removed the rib from the jig. But never mind: There are, in the box lying on the floor, enough factory-assembled ribs for the Parasol's entire wing.

Overnight the rest of the gang seems to have acquired confidence, or airplane building knowledge, or something. They're all bustling with purposefulness, like ants, or the Borg Collective from Star Trek. Everyone is assimilated. Like a single organism they sweep workbenches clean of yesterday's labors (or experiments, as in the grim case of


the rib) and set up one long jig for the fuselage. One group begins to coagulate around that, and another forms to construct the wings.

A leader emerges: Robert, a soft-spoken, friendly guy from Maryland, who seems to have decided to specialize in the fuselage. Borrowing lingo from the Allied POWs trying to flee German captors in the 1963 film *The Great Escape,* I begin thinking of him as the Fuselage Führer. Everyone sort of checks with him when something needs to be done. Under his watchful eye, the campers place the fuselage's pre-built sides in the jig and brace them into upright position. It's evident that Robert has already cut the cross-braces and some of the more intricate wood pieces that will form and brace the cockpit. Most of yesterday afternoon he was either bowed over the blueprints or the band saw, which fills the air with a scream each time it slices through wood. Since the hardest work is already done, I decide to shuffle over and get in on some of the gluing action.

The cross-bracing is mostly complete, forming the top and bottom of the fuselage, so I glue gussets (triangle-shaped pieces of wood to reinforce joints) where the blueprints call for them. Then I help glue and staple the pieces that reinforce the cockpit. Like the wing ribs, the fuselage has that strong but light geodetic construction, so we spend a lot of time cutting up spruce into pieces the width and depth of popsicle sticks, and gluing and stapling them in criss-cross fashion at every open square. The result: One light structure that's so solid it won't budge when an instructor tries to wobble it, even though for the moment it's held together by little more than staples and wet glue.

While we are occupied with the fuselage, another bunch slides some of the pre-built wing ribs onto the wing spars. I can hear the excited commotion of construction-by-committee: "Mark them here!" "Make sure the spars line..." "No—now...push more. A hair. That's it!" There follows a silent flurry of glue mixing and staple banging. It's like the scene from the Peanuts Christmas special where the gang decorates the forlorn tree: Once everyone stands back and the dust settles, there is the complete skeleton of a wing.

Like the wing, the smaller projects that make up an airplane seem to begin and continue of their own volition. Stuff just happens. Whenever someone needs a hand holding a chunk of wood or a control surface, another camper just walks up and does it. We all do it, student and instructor alike. As the Borg saying goes, "Resistance is futile."

My feet are killing me from standing on concrete all day.

## DAY 3

The Wisconsinites keep apologizing about the absence of snow and sub-zero temperatures this odd, warm winter. Somehow those of us acclimated to milder climes have been able to mask the disappointment we feel at not getting to experience frostbite.

When we arrive at the shop this morning, we have pretty much the right and left halves of the wing, a fuselage, and most of the tail surfaces. There is a noticeable increase in confidence among us novices, even above and beyond yesterday. Everyone starts pulling out staples and inspecting the previous day's work as soon as they cross the shop door, sometimes before shedding coats. Robert manages to be at work deciphering blueprints before anyone else. We're all worried that he's getting too

attached to it.
("Look what followed me home from camp, honey!")

I've been trying to conjure up the nerve to work on the some of the airplane's metal fittings, but I simply feel more comfortable dealing with wood. Then today, while the others swarm around the fuselage and wings, the instructor named Owen walks up to me and says, "Who wants to work on the engine mount?" I quickly volunteer.

Luckily for me, almost all of the smaller pieces have already been cut by my fellow campers, so Owen just needs to show me how to cut, mark, and drill holes in the aluminum tubing that will soon attach the engine to the fuselage. It only takes most of the afternoon. He sticks one of his fingers in a length of tubing to hold it flat and tight against the workbench, then takes another length of tubing and runs it perpendicularly across the top of the first piece. That leaves a nice, straight line that you can use as a guide to drill holes through the tube's exact center. Me, I do the exact same thing and the line becomes a parabola. Owen always has a bemused look on his face when he is trying to teach me something, but he never gets angry, even when I drill some six or seven tubes cockeyed.

I'm figuring out that there's really nothing magical about doing any of this airplane construction business. Basically, you drill enough holes in enough tubes and sooner or later they're going to start turning out straight and smooth every single time. Just bring along enough tubing.

Every night after supper, the EAA has some sort of event planned for us. The first two nights we wandered around the Air Adventure Museum, which is next to the shop.

It's great being virtually alone in a museum at night—it makes you feel special. Tonight we drive to a hangar where they have the EAA's Boeing B-17, *Aluminum Overcast*, opened up for us. We crawl around it like Lilliputians on Gulliver. Most of us younger sorts take turns squeezing into the bombardier and tailgunner positions, sidling along the thin gangplank above the bomb bay to reach either end. They don't have the ball turret open for us, but I doubt anyone is short or lithe enough to get inside it anyway.

Underneath the chin turret, Tom holds forth about flying the right seat of a Boeing B-29 in the closing days of World War II. He was 20 years old. He says he flew bombing missions right up to VJ Day, then he dropped supplies to American POWs. You've really got to respect anyone who would get inside one of those claustrophobic aluminum tubes while other people were trying to machine-gun him to death.

**DAY 4**

"Mike!" has become the most uttered word in the entire shop. He has a lot of patience, but he also seems a bit harried. For fun Owen and I bug him on some minor inconsistency between the blueprints and the actual components

supplied by his factory. It's like torturing a substitute teacher. To swat down our complaints, he's started repeating "I can't fly that accurate. Can you?" like some Zen mantra. You just know, though, that the Sport Parasol's blueprints and kits will have fewer discrepancies in the future.

Though Mike is pleased by the speed at which the Parasol has come together, he tells me that what we don't have time to do here they'll finish back at the factory. I ask him what will become of our airplane. "We're going to use it as a company demonstrator," he says. Suddenly, I start to feel like I just traded my best frog to Tom Sawyer for the privilege of whitewashing Aunt Polly's fence.

Owen and I begin assembling the landing gear, again mostly from pieces hewn by others. Using my newfound tube-drilling skills, I bore ever more accurate holes and de-burr them—remove the jagged edges around the hole—with a larger drill bit. I even grind down sharp metal corners in an aesthetically pleasing fashion. Just like Owen taught me. He seems pleased with my progress—except for the way I keep losing the #10 drill bit.

After working with metal, I want most to get some experience in fabric covering. The instructor named, yes, Dip, a warm, unflappable, humorous man, has taken turns walking one or two students at a time through covering one of the tail surfaces, and I want to get in on a session before he runs out of elevators and rudders. I half-expect him to hand me the traditional whalebone needle and thread, but instead he gives me a paintbrush.

Under his calm tutelage, I coat the frame of an elevator with some slimy green stuff called dope, then wrap the entire apparatus with a thin Dacron cloth, taking care to cut and lap the edges. After applying more dope, I pass over the cloth with a beat-up iron on three ever hotter settings, and in no time I have a creaseless, tautly covered elevator. Even though I can't iron a shirt (or sew a button on one), I can still cover an airplane. Or a control surface, at least. This is probably the first thing I've done here that went smoothly; sometimes I feel as if I'm the only one who's making mistakes. Though Paul has admitted that on the first day he ran his hands through his hair—when they were covered with T-88.

On the shop floor, the pile of parts grows smaller; on the benches the piles of components grow larger. The latter pile really looks like an airplane—in the same way a skeleton at a natural history museum looks like a dinosaur. If we could inject it with the DNA of a finished Sport Parasol...

**DAY 5**

The final day arrives. I've been here less than a week, but it feels like I'm leaving a bunch of old friends. Everyone has changed—not just me—they're more effusive, and they joke around more. Ron, the quiet one, has decided to order the kit. "I'm feeling 15 to 18 years younger than when I walked in here," he says.

The same goes for Jack, who was shy and retiring at the beginning. Like me, he wasn't sure whether he'd have fun at camp. "I didn't know how much the others knew that I didn't, and I wondered how I'd fit in," he says. "But I've really enjoyed it, and I had a good time." He adds that he's learned a lot, and not just about specific aircraft construction techniques. "A lot of this stuff is fairly forgiving," he explains. "You're allowed to make a few mistakes, and you always have the latitude to go back and do it again."

Then there's Paul. "I tend to be overly critical on my building skills," he says. "But there was a big difference between what I would have passed and what was acceptable to Mike. I would have spent thrice the amount of time doing things over and over again." And John says he's now psyched to go home and work on his own kit. "I was here to get some relief from the stress of work and have some fun," he says. "Mission accomplished. I have relit the flame of building emotion."

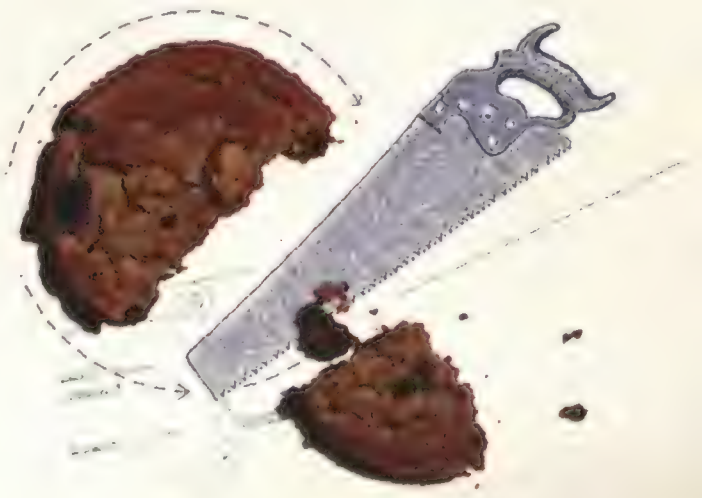
We know now that we're not going to finish, so today everyone spends more time stepping back and admiring his work. Now it's unmistakably an airplane. I mean, no one could wander in here and ask "Whaddya buildin'? A canoe?" With the fuselage lying on its back like a dying insect, we've bolted the engine mount and the landing gear—I built those!—into place, and someone's slid the tailwheel into position. The tail surfaces have all been covered and are ready to go on. Jim and Debbie are beginning to work on one aileron while David and Tom are working on the other. Mike says that later in the afternoon they're going to clear a space on the floor and put all the components together. Then they're going to load the assemblage on a flatbed truck and take it to his factory in Tennessee.

But there's a lot of work left: finishing the ailerons, rigging the control surfaces, wiring the instrumentation, and installing the engine. They're the kind of time-consuming details that don't add up to much when you step back after a hard day's work. We're at the stage that a lot of homebuilders don't get past. "I tell people who say they want to build a homebuilt to spend a year just making fittings," I overhear the instructor named Jim telling some of the other instructors. "If they're still enthused after that, they have what it takes to build an airplane."

I am the first camper to leave; my flight departs in an hour. While Linda waits by the shop entrance, ready to chauffeur me to the airport, I have time for some quick handshakes and a few hugs with my fellow campers. Then I'm out the door. As I look back, Owen is watching the gang tightening bolts on the engine mount, while Tom supervises aileron construction. And Robert is keeping a paternal eye peeled while a couple of the instructors debate the positioning of the tailwheel on his beloved fuselage. That's the way I leave them. As far as I know, they're still there.

I can't wait to go back next year.

*For more information about the EAA Adult Air Academy, call (800) EAA-EAA9; e-mail: education@eaa.org*



Every assembly line needs a beat to synchronize its mechanical march, and on the 172 Skyhawk assembly line at Cessna's new light-airplane factory, it is supplied by a green button next to a giant garage door. Fred Albin punches the button and a squawk box produces a loud, two-tone noise that echoes through the six-acre production floor.

Albin tows Number 471 off to the paint shop with a jeep. The rest of the workers on this line know from the blare that it's time to move up the other airplanes. They free them of air-tool hoses and electrical cords and push them forward by hand, the tires rolling silently on the gleaming gray concrete. A minute or so later the umbilicals are back in place and the rivet guns, power screwdrivers, and metal snips are in action again. Two 172s and a 182 Skylane, nearly half a million dollars' worth of airplane all together, will go out the door today.

You may be surprised to hear that the classic piston engine light airplane, which some declared dead years ago for a variety of reasons, not the least of which was liability law run amok, is alive at Cessna and selling once again, even though the price for the updated versions may leave you slightly breathless. Cessna chairman Russ Meyer Jr. is making good on a promise to Washington. The day after President Clinton signed the General Aviation Revitalization Act of 1994, cutting off the manufacturer's product liability as of each airplane's 18th birthday, Meyer announced that Cessna would reverse its 1986 decision to stop building single-engine light aircraft. Within less than two years, Cessna had picked out a location, built 400,000 square feet of plant from the foundation up, recalibrated its jigs and tools, and restarted production of the 172 Skyhawk and 182 Skylane.

*New workers, new plant, new and improved version of a classic: The 172s and 182s taking wing in Independence, Kansas, may provide the push the light aircraft market has been waiting for.*


A second surprise is that all this is happening outside Wichita, Kansas, the center of gravity for such aircraft since the 1920s, when Clyde Cessna, Walter Beech, and Lloyd Stearman opened the Travel Air Company and later their own factories. Like Rosie and her fellow riveters, a good many people now building Cessnas in Independence, Kansas, a hundred miles to the southeast, probably expected to live out their careers as farmers or mechanics or anything but workers handling rivet guns and bucking bars in an airplane factory.

Further, according to the welcome mat at the new plant, Independence (population 10,000) is suddenly Lightplane Capital of the World. Working out of three new buildings at the municipal airport, whose spacious runways date back to the days when the facility served as an old Army Air Corps training base, the men and women of Independence assemble all of Cessna's single-engine models except the utility transport 208 Caravan.

It's shortly after 10 a.m. on a Monday. From where I stand, looking toward the exit doors, the left-hand production

by James R. Chiles

*Photographs by Jay Koelzer*

## Primer Yellow Dogs, Eight Balls, and the Back of the Bus are helping to bring Cessna's singles

# BACK ON THE LINE


*For the people of Independence, the Cessna startup meant 800-plus jobs. The majority of new hires (right) had no aircraft experience. Cessna's team approach has brought together former auto mechanics, farmers, and school custodians to build airplanes.*

line builds the 206 Stationair and the 182 Skylane, priced and sized mainly for business use; the production line to my right builds the 172 Skyhawk, more of a family or small-business airplane; and the center production area puts together the wings for all models.

Aircraft construction here is a low-key affair, without the jammed, clockwork look of a high-volume auto assembly plant. Whereas Saturn's Tennessee plant cost $1.9 billion and works two shifts a day, six days a week, the complete cost of Cessna's facility in Independence, including startup, was a modest $75 million. Parts roll to and fro on wheeled carts or forklifts rather than on relentless conveyors demanding the turn of a wrench timed to the second. In two areas away from the main floor's hustle, workers construct upholstered seats and weave electrical harnesses to match custom orders for radios and navigation equipment. The east side of the main floor puts together small mechanical parts and subassemblies that feed into the final assembly lines. Tail components and control surfaces come from Cessna's plant in Columbus, Georgia. Cessna's Pawnee Division plant in Wichita, where such airplanes once underwent final assembly, now stamps out aluminum for the airframe and ships it here.

Like so many woodpeckers rapping hither and yon in a forest, rivet guns call out from all over the factory floor, chattering in one-second bursts. Watching the work flow along the Skyhawk line, I learn from area leader Mark Drumeller that fuselage no. 476 is six stops from completion (each stop is four hours). It has a tail, gleaming Lycoming engine, both doors, but no wings. That's the job of Steve Slayton, who pushes a blue dolly toward the wings department. He returns in a few minutes with two 172 wings, parks the cart in an aisle, and rounds up three men to help. The four raise the 100-pound left wing up and over their heads and, walking in step around the red toolcarts, bear it like an emperor's litter to the fuselage. Slayton, calling out terse directions to tilt the wing this way or that, wields a ball-peen hammer to drive home the four main bolts attaching the wing to the fuselage and a diagonal strut. "Four guys carrying a wing are

faster and smoother than two with an overhead crane," Drumeller explains.

Slayton once repaired diesels at a locomotive shop in nearby Coffeyville; some of the tools he used weighed as much as a whole 172 wing. "My back is doing ten times better than it was before," he says. Slayton is one of the few around here with aircraft experience, having spent four years in the Navy as a mechanic on the Grumman F-14 before taking the locomotive job.

*Workers like Billy Robinson (below) keep Cessnas rolling out at a rate of three or four a day. The company likes to keep a backlog of orders; a customer who orders a Cessna today will wait three months to fly it home (bottom).*

Judging the wings sturdy, Slayton and his fellow wing-walkers head off to other tasks. This is not a line where one worker turns the same bolt with the same wrench all day long. Cessna has organized the 34 workers in final assembly into four teams of cross-trained workers who move the airplane through the six-day assembly process, with each team passing airplanes off to the next. The teams have named themselves, says Mark Drumeller: There's BOB, short for back of the bus, who start final assembly by joining large fuselage parts; the Primer Yellow Dogs, who attach doors and instrument panels; MOB, Middle of the Bus, who install control surfaces and interior mechanical systems and check for problems as spaces are closed up; and the Eight Balls, who finish the airplane by mounting interior trim and seats. Final inspectors Doug Thompson and Mike Baima range up and down the line, signing off each airplane's notebook at critical points or directing more work as needed. As part of the certification process, the Federal Aviation Administration has delegated all final inspection to Cessna, standard procedure at aircraft factories.

Such teams are an evolutionary step beyond the classic assembly line approach, which has each worker isolated at an individual station and responsible only to his foreman for slip-ups. Instead, when key indicators such as scrapped parts and production targets are measured, the team is responsible as a group. "Cessna is one of the few companies I know of that has gone at the team approach a hundred percent," says Drumeller.

Workers tell me they like working for Cessna, particularly compared to other places where they've worked. "If somebody threw a fit here, it would be so out of place," Ronnie White says during lunch. "At 3:30 you get to go home and you can leave the job here—you don't go and stew about it, all mad over what somebody did back at work."

Standard new-employee training covers sheet metal work, blueprint reading, and a brief personality dynamics course on how to fit into Cessna's team workplace. For those who want to fly on the weekend what they build during the weekday, the company pays healthy subsidies to offset the cost of flight training. Fifty-one employees are in the program now.

There's also a course on flight safety that explains how niggling problems on the ground can turn into big ones in the air. Pre-shutdown Cessna 172s once had a problem with seats that slid loose on the tracks at bad moments; now, with new rails, reinforcements in the floorboards, and a double locking system, they're built to hold tight even under 26 Gs. Workers are the first line of defense in the battle against mishap, and Cessna promises they won't be punished for bringing their mistakes to light.

"If you've got a problem, you're supposed to stand up and say so," says Fred Albin. "When I'd been here about a week and was working on the engine cowling, one day I ran the reamer too far and went into the fuel filter. So I went over to the desk and said that I messed up the fuel filter. They said 'No problem, go and get a new one, it's no big deal.' Well, I found out later that that thing cost $375, but they never said a word about it."

After lunch I watch Albin and his

team at work. Along with Kel Ibrahim, a Malaysian immigrant and former U.S. Air Force aircraft mechanic, Albin fastens and adjusts the stainless steel cables connecting the rudder pedals and yoke to the control surfaces. Ibrahim handles the tail surfaces, working from inside the tailcone at some points; Albin adjusts flaps and ailerons on the wings, hurrying from one side of the airplane to the other to check an inclinometer on flaps here, or adjust a cable under the instrument panel there. He can't take a shortcut through the passenger compartment because it's always crowded with workers or technicians. (Last July Cessna increased training and inspection stations for the 172 line after an airworthiness directive was issued requiring checks for misrouted control cables in all the 172s built at the new facility.)

Other work by the MOB team is a combination of attachment, adjustment, and double-checking. Ronnie White and Brandon Radell install external fittings, attach registration plates, and check inside wings and floorboards for metal and plastic scraps and stray rivet heads that might hang up a control cable. Billy Robinson and John Royer handle outside jobs like mounting the nose cowling and installing wing fairings. Another team works in parallel with MOB to check out the electrical system and install the final interior trim and upholstery.

The plant rolls out four airplanes a day, and it plans to double that to a rate of 2,000 aircraft a year if orders justify. Cessna is determined not to repeat its pre-shutdown routine of overstocking inventory, which left unsold airplanes whiling away the days on dealer ramps. "We build to meet the demand now and try to keep three months of orders backlogged," says Jennifer Whitlow, marketing communications manager for single-engine aircraft.

Though the plant went up ahead of schedule, aircraft production has not kept pace with Cessna's original projections, which figured on 1,000 airplanes out the door in 1997 alone. However, Cessna announced in mid-June that it plans to deliver 800 single-engine aircraft this year.

"We've come across our challenges and we're working through them," Whitlow says. "We've decided to grow at a smaller rate." Employees tell me that a shortage of parts and the need to break in a new workforce have tilted the original production goals downward. Whitlow says the company expects the single-engine line to break even sometime this year.

One person looking on with gratification at the light-airplane revival at Cessna (and Piper) is Ed Bolen, president of the General Aviation Manufacturers Association. Bolen says that as a pilot, he realized Cessna's shutdown of piston engine production in 1987, and even more vividly Piper Aircraft's filing for bankruptcy in 1991, meant that an era had ended. Annual domestic production of entry-level airplanes dropped from 14,398 in 1978 to 444 in 1994. Aviation schools had trouble replacing their trainer aircraft, mechanics found other jobs, and the small-

*Under the cowling (above) is a fuel-injected Lycoming IO-360, which means no more carburetor—and more importantly, no more carburetor ice. Epoxy primer protects the entire airframe from corrosion (right).*

*"Four guys carrying a wing are faster and smoother than two with an overhead crane," says Mark Drumeller, as Steve Slayton (in lead) reaches for the sky. Below, mechanics Harold Click (in cockpit) and Larry Wright fire up a Lycoming fuel-injected engine for its first in-airframe run.*

er flight training and airplane rental operations shut down. "The whole general aviation infrastructure was allowed to crumble for almost a decade," he says, even though the downsizing of military aviation made general aviation aircraft more necessary than ever as a starting point for tomorrow's professional pilots. Today, Bolen adds, Cessna is back, and over the last six years Piper's employment has climbed from 41 to more than 700. "Now the biggest challenge they face is finding enough employees," he says.

The starting wage at the Independence plant is $8 an hour and has pulled in workers of wide experience, though of 800-plus workers at the plant, three out of four had no prior aviation experience. Of workers on the Skyhawk final assembly line, Mark Drumeller says, 32 out of 34 began without aircraft work experience. The great majority of workers here are from the surrounding area rather than relocated Wichitans. During my visit I met auto mechanics, farmers, an electrical worker, and a gas pipeline technician.

Cessna paychecks apparently came at a good time for many. Ronnie White, former school custodian, considers himself one of the lucky ones. "The economy was so depressed before Cessna came, I couldn't even get past the factory guards to apply for a job at the lawn mower factory," he says during lunch. "Those plants only wanted college graduates. There were so few jobs around I guess they felt they could pick from just the best." Fred Albin, previously shop foreman at a used-car dealer, had to hunt up other work after the owner began talking retirement. Local manufacturers near Independence include a car components maker, a boat builder, and an assembler of beverage delivery trucks. Arco Petroleum once had a headquarters here but moved a few years back. Before coming to work at Cessna, Nancy Cain watched her employer, Emerson Electric, begin shifting assembly work to Mexico. "They hadn't closed down our line yet, but I saw the writing on the wall and wanted to choose my own fate," she says.

All the new faces are a bit jarring to old-time Cessna hands. "There's only a small handful of Wichita people here," says Dan Andrew, who works in the flight test building. Andrew began with Cessna in 1976, was laid off twice during general aviation's market swings, and is now lead pilot among the production flight test crew. "At first I didn't recognize anybody, but then there were

some Wallace guys," he says, referring to the Wichita plant that produces Cessna's larger aircraft. "I thought, *Now here's somebody I can talk to.*"

Another of the deep-dyed Cessna workers so rare on the Independence factory floor is Roy Atchison, retired from the Pawnee plant but back as a temporary contract worker. He's tall and looks on the young side of his 67 years; he tells me with a laugh that when he walked into a local hardware store to buy a steel rule, the clerk asked if he needed it for starting Cessna's sheet metal school. "I told him I did that more than 40 years ago," Atchison says. Starting out on the horizontal stabilizers that Cessna was building for big Air Force bombers, Atchison spent the bulk of his career in production and parts for single-engine airplanes.

"It's the only company I ever worked for," he says. "A lot of people might not feel this way anymore, but the way I look at it, Cessna fed my four kids and educated them, so I feel like I owed them my coming out of retirement for a little while." Now he offers tips and techniques to the wings department.

Ironically, as part of the layoffs that followed Cessna's production cutbacks in 1987, Atchison and other single-engine workers at the Pawnee plant had so much seniority that even though their job at Cessna was gone, they were able to displace workers on the surviving lines that produced the larger aircraft—the utility transport Caravans and Citation business jets. "It caused a little friction between the two plants, but we worked through it," Atchison says. He finished his career building spare parts for the little airplanes that Cessna had stopped selling.

Atchison explains that many of the old jigs once used at the Pawnee plant to align the parts for assembly are still in action at Independence. Some date back to the 1950s. All told, 172s come together pretty much the same way they did during the boom years. The pace is slower; now workers roll airplanes to a new station two or three times a day, but back then some airplanes waited only 15 minutes before rolling on. When I compare the look of the factory floor now to old photographs of the Pawnee plant, the most noticeable difference is the primer coat on all parts in today's airplanes. Bare burnished aluminum is gone forever—Cessna found that owners want to fly these airplanes far longer than unpainted aluminum will resist corrosion.

The new products are quite similar in shape and size to pre-shutdown models of 10 years ago, but according to Cessna the improvements are major. Besides the epoxy base coat, other changes include the latest navigation and radio gear, a rather luxurious interior, new inertia reel seatbelts, and a fuel-injected Lycoming engine that eliminates the carburetor, which was prone to ice up when you pulled the power off in humid air.

"I hope never to see the 172 go away," says Jennifer Whitlow, who did part of her flight training at Embry-Riddle Aeronautical University in Florida and was once dismayed to hear during the dark days of the shutdown that her school had decided to replace its old Cessna trainers with imports. Now she reports that Embry-Riddle is back on the Cessna wagon.

I ask her how working with piston engine airplanes compares to working with the big Citations. "When you're handling business jets," she says, "you're working with flight departments and CEOs, or pretty wealthy people if they own one personally"; the jets sell for $3.1 million to $15 million. "I like selling the little airplanes. The customers are real people, like farmers and ranchers. They've babied the old airplane along for years, saved up their dollars, and now they're really thrilled to have a brand-new one."

And it does take some saving. Without options, a factory-direct 172, which seats four and carries 120 pounds of baggage and 56 gallons of fuel, starts at $133,700. The more powerful 182—

with 200 pounds of luggage and 88 gallons of gas—costs $217,900. These prices, announced when Cessna rolled out the new airplanes at the Oshkosh airshow in August 1996, caused dismay among some pilots despite Cessna's reassurances that after inflation the price is about the same as it was in 1986. The company recently debuted finance programs that, for example, bring the monthly payment for a 172 to $995 for the first year, eventually increasing to $1,295.

In attempting a single-engine comeback, all has not been easy or predictable for Cessna. Today's market being what it is, there's about zero chance of returning to the production peaks of 1965, when Cessna's four lines pushed out a piston engine airplane every 23 minutes. But workers like Fred Albin are distinctly upbeat even so. "Give us four or five years and this assembly line will really be in great shape," he says. Just looking down the line offers some reassurance. Familiar on the outside, safer and classier on the inside, three-wheeled Cessnas creep daily toward the doors. The population of entry-level airplanes is climbing back from extinction and it's hard to know who's happier about the whole thing—people once hungry for new Cessna singles, or the people of Independence who came to build them.

*"We've decided to grow at a smaller rate," says Cessna's Jennifer Whitlow. If orders justify, Cessna will double its production rate to 2,000 aircraft a year.*

by T.A. Heppenheimer

You don't see the fire—hydrogen burns a pale, almost colorless blue—but you hear it. It out-roars the turbomachinery and exhales steam like a volcano. When the steam strikes water that has been sprayed into a flame deflector—an enormous curving duct beneath the rocket engine test stand—the water also flashes into thick white steam that billows and drifts, traveling hundreds of yards, then rising into the sky.

"We create our own rain cloud," says Dave Geiger, a contractor at NASA's John C. Stennis Space Center in southern Mississippi. At about 4 p.m. most weekday afternoons, the center test-fires a space shuttle main engine—either to certify a new one for flight or to collect data on replacement parts still in development—and puts on a display of power you usually see only in nature. "It's amazing to watch that engine run that long and the noise and the energy that it creates," says Geiger, the site director at Stennis for Boeing/Rocketdyne Propulsion and Power. "When you go to a shuttle launch, you see the vehicle for maybe two minutes. You hear it, but it's very short. Here, we go full mission duration: eight minutes, 40 seconds. An astronaut was here who had never watched a test before and he told me he was glad his wife hadn't seen that before he flew."

Like shuttle launches, the tests of the space shuttle main engine (SSME) are stirring but also give the impression of being routine. Maybe it's the Monday-through-Friday (and sometimes Saturday) schedule, or maybe it's the accessibility: Stennis has a visitor's center, and anybody can stop, put on ear protectors, and watch a test firing. Maybe it's the fact that it's been a while since something has gone very wrong. The last time was more than a year ago, when the wall of a well-used exhaust nozzle collapsed and caused, as Geiger puts it, "fairly significant damage."

But no one at Stennis, or at Boeing/Rocketdyne Propulsion and Power in Canoga Park, California, where the engine was invented, or at the Marshall Space Flight Center in Alabama, which oversees its development, or at the Kennedy Space Center in Florida, where it is put to work, regards anything about this engine as routine. The memories are still too fresh of how hard it was to get it right.

Before the U.S. space shuttle, rocket motors made one flight, then dropped into the Atlantic, or, if they were Russian, fell onto empty steppes in central Asia. But the shuttle was to be the world's first reusable launch vehicle, and in 1972, NASA, still flush with the triumph of Apollo, set the shuttle engine's life expectancy at 27,000 seconds without overhaul. This meant, the agency would later determine, that the engine would fly 55 times. The contract winner, Rocketdyne, had supplied the J-2 engines for the Saturn V upper stages, and company managers had reason to be confident.

"We never wore out an engine of the J-2 type," recalls Paul Castenholz, who had directed its development. "We could run it repeatedly; there was no erosion of the chamber, no damage to the turbine blades. If you looked at a J-2 after a hot firing, you would not see any difference from before that firing. The injectors always looked new." The J-2 had been built as a conventional design, meant to fly only once. Nevertheless, one unit ran 103 times on a test stand for a total of six and a half hours without overhaul. Castenholz and his colleagues needed to get the SSME to run in flight only one

*Breathing fire from a hydrogen vent stack, Rocketdyne's A-3 test stand in California's Santa Susana Mountains thunders with the test of a space shuttle main engine.*

During the development of the space shuttle main engine, turbines broke, bearings melted, engines exploded, entire test stands went up in flames. Somehow Rocketdyne tamed the beast for not just one flight, but 55.

# 27,000 SECONDS IN HELL

BOEING/ROCKETDYNE PROPULSION AND POWER

BOEING/ROCKETDYNE PROPULSION AND POWER

*SSME component testing began at Rocketdyne's Santa Susana test facility in 1974. Testing there was suspended in 1977 after two fires but resumed at the recommendation of a Congress-sponsored study.*

more hour. But once the first SSME unit was assembled for testing in 1975, it took 37 engine tests over the course of eight months, with 13 turbopump replacements, to get it to run continuously for five seconds.

"All the wear, all the torture of engine components happens during the start," says Kevin Hoshstrasser, a Boeing/Rocketdyne manager at the Kennedy Space Center. Liquid oxygen is denser than water, he points out, and the pump pushing that heavy stuff has to go from a dead stop to 30,000 rpm in three seconds. "You could get your Ph.D. in systems engineering just explaining the SSME start sequence," he says. Here's the Cliff Notes version.

The SSME is the first operational rocket engine to use staged combustion: The propellants are partially burned in two combustion chambers. The exhaust from those "preburners"—hot gas—powers two high-pressure turbopumps before finally entering a third, main combustion chamber (see "Double Duty," opposite).

The sequence of ignition is controlled by the computerized operation of five valves: a main fuel (liquid hydrogen) valve, a cooling system valve, and three valves that regulate the flow of oxidizer to the engine's three combustion chambers. The oxidizer valves are, in effect, the throttle; they control the engine's power level. (When the SSME is throttled during the shuttle's ascent through the atmosphere, the commands to the engines adjust the positions of those three valves.)

Rocketdyne project engineer Robert Biggs says the team knew that synchronized operation of the propellant valves would be critical; five years of studying computer models before the first start was attempted had proved that. "We could control [the valves]—make them go precisely where we wanted," he recalls. "The difficulty was in learning where we wanted them to go."

Each valve must open partially to a precise position, then partially close, then adjust position again at exact times to accommodate the pulsing in the flow of cryogenic liquids (see "Start Me Up," p. 79). At the same time, each combustor and turbopump in the engine is affected by the actions of all the other components. Because of the extraordinary performance being designed for the SSME turbines and pumps, the engineers knew the components would be extremely sensitive to even the smallest changes in the flow of propellants.

The high-pressure fuel turbopump, for example, is only two feet in diameter and weighs only 750 pounds but generates 75,000 horsepower. (The boilers and engines that drove the *Titanic* produced 55,000 horsepower and filled an acre of space.) The fuel turbopump increases the pressure of the hydrogen from 250 pounds per square inch to 7,000 pounds per square inch, high enough to push a column of water to a height of three miles.

The pump's turbine is a mere foot across and gets kicked into motion with a blast of hot gas from one of the pre-burners, a powerful rocket engine itself. Because the turbine is so compact (with a small amount of mass to resist a force applied on it), a kick this strong could accelerate it into a destructive overspeed, unless somehow a resistance is created downstream to restrict the flow of hot gas passing through it. Just such a countering force is provided by the burning of propellants in the main combustion chamber. The resulting pressure within this chamber provides an important force that prevents the turbine from overspeeding. The starting sequence, therefore, is critical: Combustion must commence

in the main combustion chamber within a fraction of a second of the time the high-pressure fuel turbopump gets its first kick. If the main combustion chamber starts a fraction of a second late, the turbopump could spin out of control; if it starts a fraction of a second early, the fuel turbopump hasn't supplied enough hydrogen and the resulting oxygen-rich propellant mixture could burn engine hardware.

"An error in valve position of 1 percent or a timing error of a tenth of a second can lead to significant damage to the engine," Biggs would later write in a professional journal.

"It was a tougher engine to develop than anyone envisioned in 1972," says J.R. Thompson, then NASA's SSME program manager. (Thompson retired as the Deputy Administrator of NASA in 1991 and is now a vice president at Orbital Sciences Corporation.) "We started out saying that we were going to fabricate turbine blades that would stand up to anything and when we got well into the development program, that became a dream."

The high performance demanded of the engines was based on a Department of Defense requirement: The SSMEs had to produce enough thrust to get a 65,000-pound payload to a 115-mile circular orbit from the Florida launch site. As it happened, that payload never materialized and the shuttle today is rated for a 53,800-pound capability. Space station components, which have to be carried to a 220-mile orbit at an inclination of 51.6 degrees from the equator, can weigh no more than 41,000 pounds.

"We started with a stout, tough target, and we backed off as necessary," says John Yardley, then NASA associate administrator for spaceflight. "We were willing to take a lower [payload] weight on early flights." There was a grander design in the shuttle engine program, however, than accommodating any one specific payload. NASA wanted to advance rocket engine technology, just as it had done with the Apollo program.

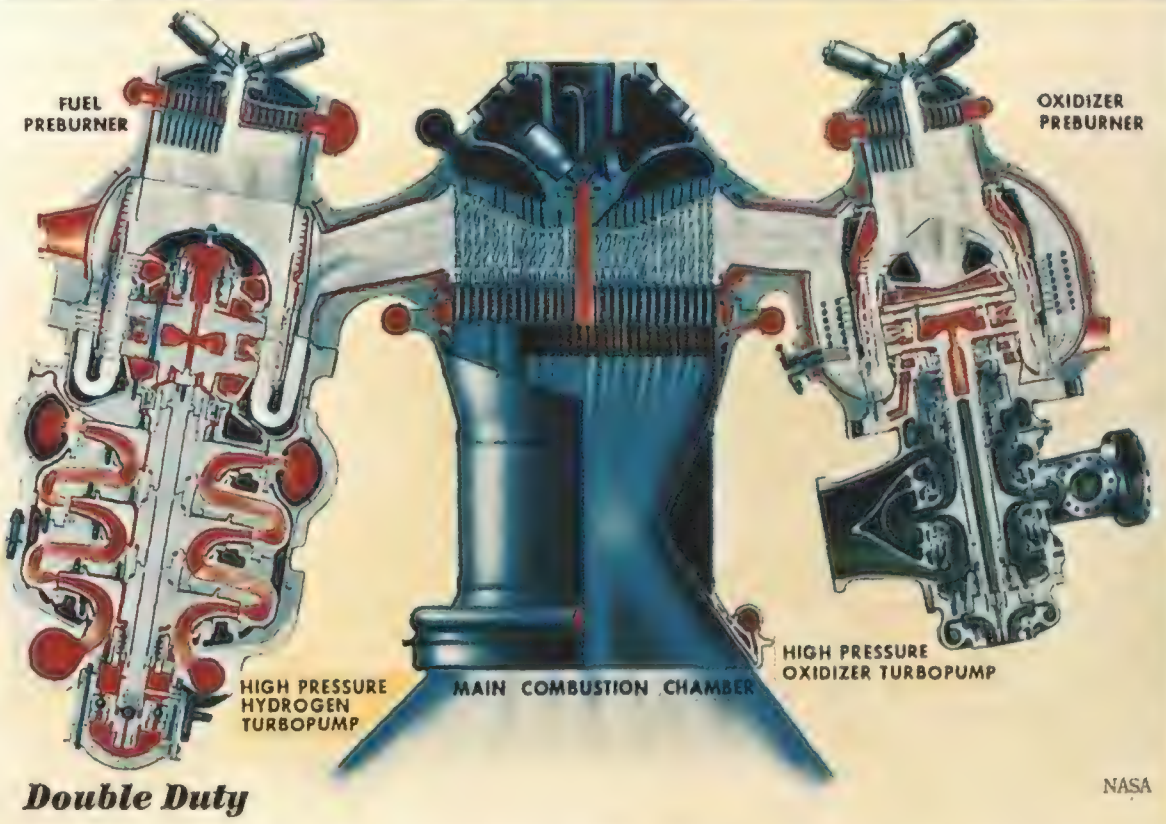
"Developing an engine is like a 10-year cycle out of your life," says Joe Stangeland, Rocketdyne's director of turbomachinery. "I'd lived through it on Atlas, on Thor, and Apollo. On the [Apollo program's] J-2 engine, we had chamber pressures at 1,000 psi at the most. All of a sudden you're gonna run pumps all the way to 8,000 psi. When we started out, people didn't know how metals were going to react at pressures of 8,000 psi."

Many of the problems the team members ran into, however, were not complete surprises. They knew, for example, that they'd need a way to keep bearings from overheating, especially those mounted within the hot end of the fuel turbopump, which was heated by the preburner's exhaust. They designed the cooling system to channel liquid hydrogen down the center of the turbopump's shaft, a design Stangeland calls "putting a refrigerator in the oven." So when the turbopump failed in early tests, the bearings weren't the only place the engineers would look for an answer.

They quickly determined that the shaft of the turbopump, which was supposed to rotate while held tightly within its bearings, was instead spinning like a pipe rolling around the inside of a barrel. The phenomenon—"subsynchronous whirl"—caused the pump to vibrate and wore out the bearings almost immediately. To solve the problem, Stangeland and his colleagues had to stiffen the shaft and support it more firmly. "We scanned the entire world to find people who could help us solve our problems," Stangeland says. "You might say we wrote the book on rotor instability."

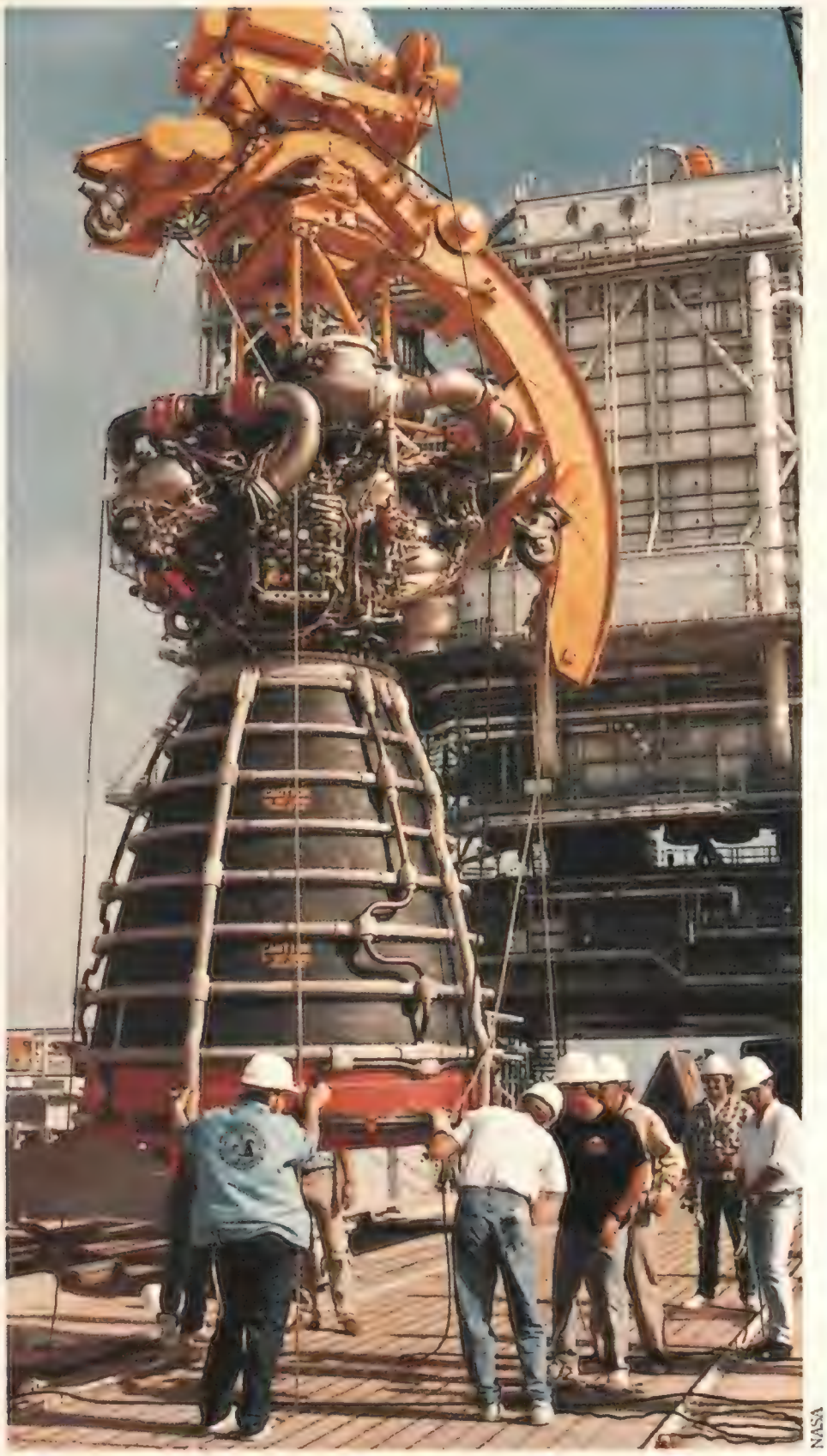
A major source of the whirl was indeed a cooled bearing, which would overheat, soften, and fail. The investigation showed that in their calculations of how much hydrogen would be needed to cool the bearings, the engineers had not anticipated a characteristic of its flow. As it streamed, the hydrogen formed a vortex—a tiny whirlpool—that interfered with the flow; the bearings were getting less coolant than needed. "We put a little [paddle] in the flow," says Stangeland. It was about the size of a quarter—and it took eight months to discover this solution. "That kills the vortex. The bearing was cooled and away we went."

With the start sequence in hand and the fuel turbopump in reasonably decent shape, it now was possible to reach for longer run times during subsequent tests. These quickly brought fires and explosions, the results of problems in the oxygen turbopump, which was much harder to develop. When the fuel turbopump failed, it would simply shut down and cause the engine to quit. But when the oxygen turbopump failed, it often started a fire. In his journal article, Biggs writes of the "fiendish nature" of such failures, for "once a fire has been ignited in the high pressure liquid oxygen environment, it readily consumes the metals and other




***Double Duty***

In the SSME, hydrogen is mixed with oxygen and partially burned in two small combustion chambers, or preburners. The product is hot gas exhausted at high pressure. The twin blasts of hot gas supply the power to drive two turbines, which, in turn, drive two pumps—one moving fuel, the other oxygen. The turbine exhaust gases are then burned fully in the main combustion chamber.



NASA

*Testing doesn't end with development engines. Three production models were replaced on STS-49 in April 1992 when a preflight firing showed irregularities (left). Instrumentation was key to that discovery and to failure analysis after a high-pressure oxidizer turbopump burned (below), since little physical evidence remained. Rocketdyne demonstrated staged combustion in 1971 by briefly firing a combustion test assembly without turbopumps (opposite).*

namics of the propellants; the test data, which reported temperatures and pressures and used high-speed photography to help establish the sequence of events; and the test history of components.

At times the complexity of the test facilities caused more problems than components being tested. One turbopump test stand had 2,000 valves that all had to work right. In one case the test instrumentation destroyed an engine. To measure propellant flow rates, test engineers frequently install flow meters with small turbines in the plumbing. But the Rocketdyne team feared that on a test stand, such a turbine itself would break and its pieces would tear up an engine's turbopump. "We said: No turbine flow meters," says Stangeland. "Someone had the brilliant idea of a non-obtrusive flow meter. It was a very bad engineering decision. I did the failure analysis on that one."

An ultrasonic flow meter had been attached to the outside of an oxygen line for a test in August 1982, more than a year after the shuttle's first flight. Stress concentrations from the welding blocks fixed on its outside wall caused the duct to fail, and the oxygen flowing through it leaked out. Free flowing liquid oxygen is something you don't want in a rocket engine.

"The clue—and the solution—was always found in the data," says J.R. Thompson. Nevertheless, the oxygen turbopump continued to fail as engine tests reached for more power and longer running time. When the first space shuttle flew to orbit, in April 1981, its astronauts had the plea-

materials that make up the hardware. In most cases, the part that originated the failure is totally destroyed, leaving no physical evidence as to the original cause."

Biggs recalls that following such a fire, "the program comes to a screeching halt until we find a reason for it, and prove it's okay to start again. There's no other thought except 'We've gotta find out what did this.' A lot of times this required working seven days a week. You cancel your vacation, which I've done. Or you get called back from vacation, which I've done."

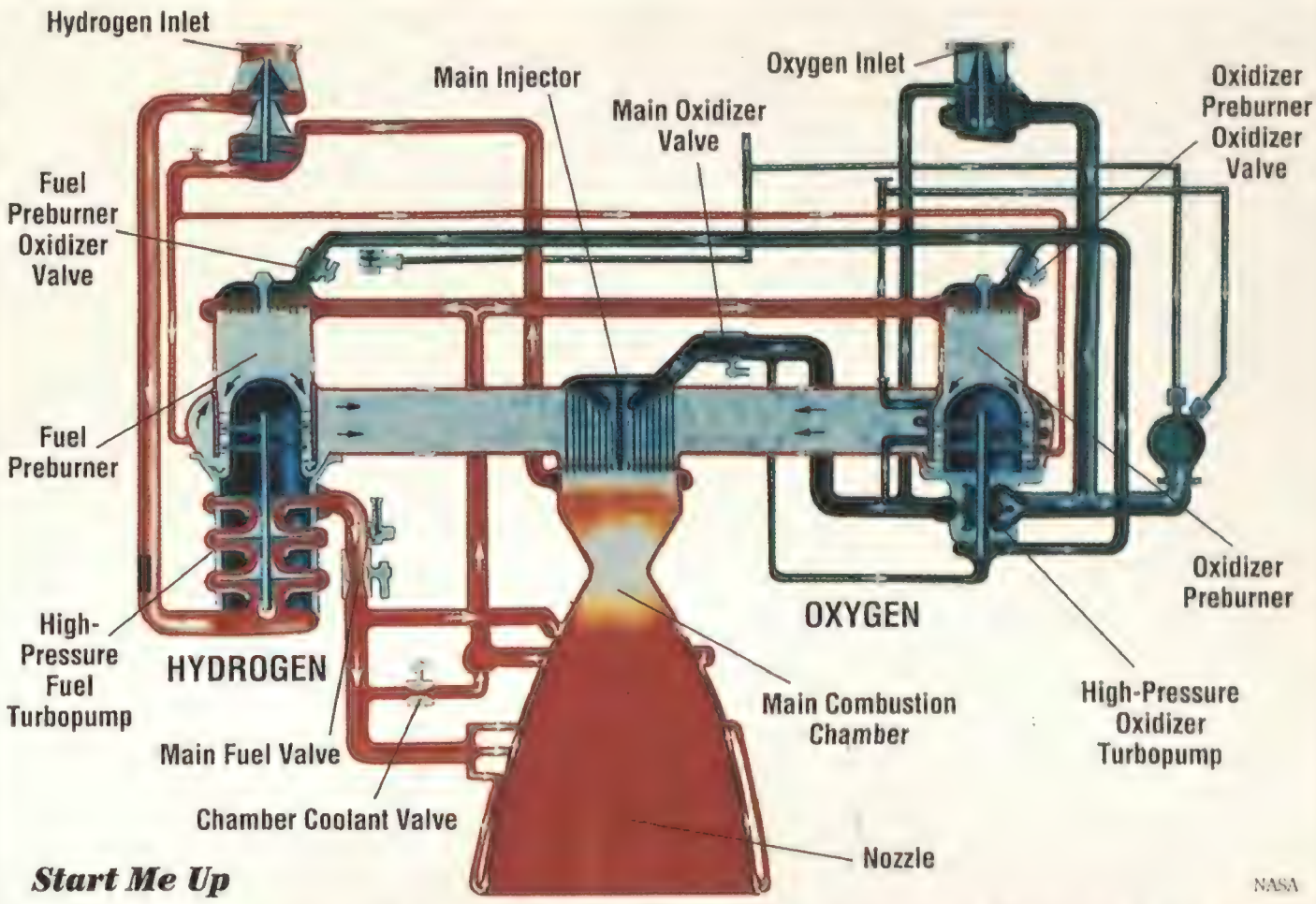
Test engines were monitored by extensive arrays of instruments, and, even when a turbopump was burned beyond recognition in an oxygen fire, engineers succeeded in reconstructing the reasons for failure. The investigations, says Stangeland, always depended on four categories of evidence: the hardware, which would sometimes be studied under a scanning electron microscope to determine the cause of fractures from their patterns of propagation; analysis, which included studies of dynamic vibrations and structural margins, the chemical characteristics of the metals, and the fluid dy-

BOEING/ROCKETDYNE PROPULSION AND POWER

sure of knowing that an engine had experienced an explosion of the oxygen turbopump as recently as the previous July.

The six years of testing between the first hot firing at Stennis and the first shuttle mission were intense, recalls Thompson. "We had 11 major failures that were catastrophic," he says. "None of us expected it to be failure-free. We never learned as much as we did during an investigation, coming out of a failure. That's when you're really on the steep part of the learning curve," he says.

The view in Washington was less sanguine. In December 1977 Senators Adlai Stevenson III and Harrison Schmitt, the latter a former astronaut, asked the National Research Council to review the SSME program. The review panel included Richard Mulready of Pratt & Whitney, who had expected to win the SSME contract for his own firm. He had no love for Rocketdyne.




NASA

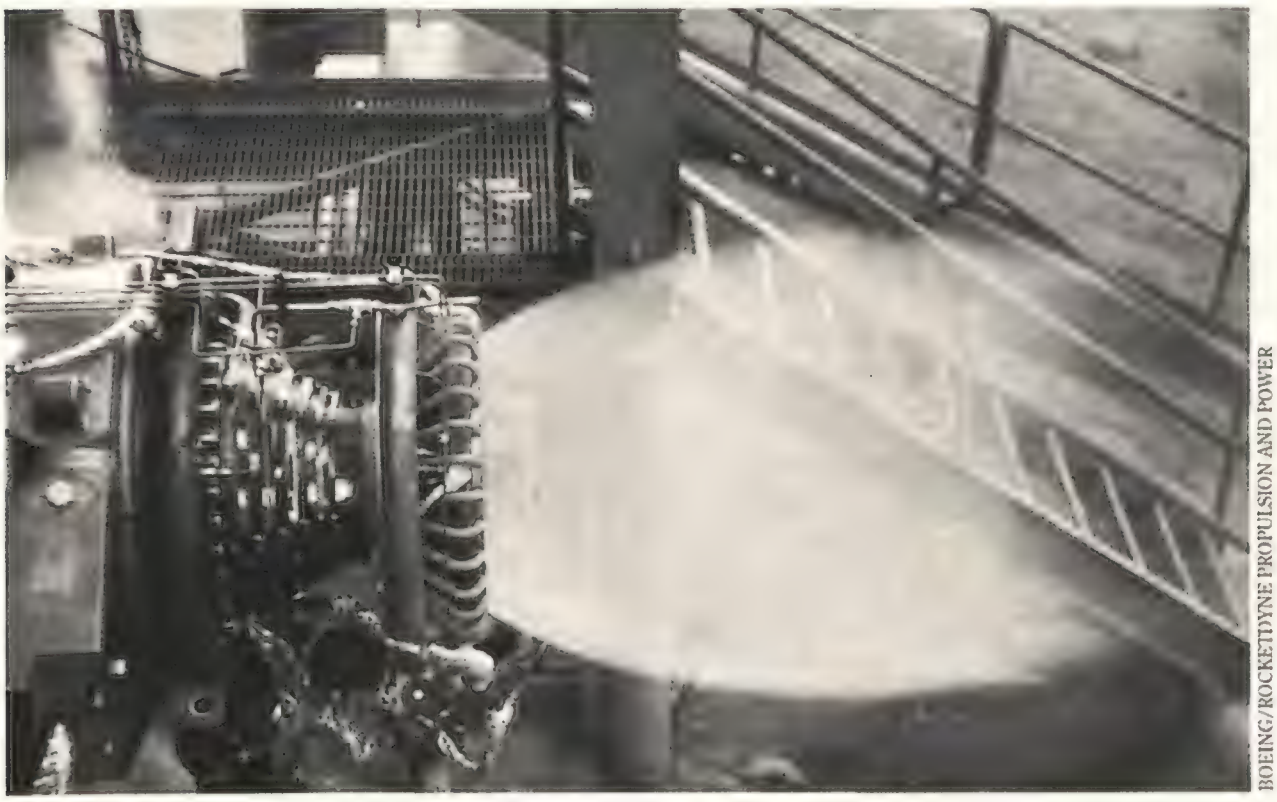
***Start Me Up***

When the engine receives a command to start, its main fuel valve opens fully and all chambers fill with liquid hydrogen. Merely from the heat of the metal with which it comes in contact (and at –475 degrees, it's a lot colder than anything it's likely to touch), the hydrogen expands. In doing so it imparts enough energy to begin to power the turbopumps. The fuel's rapid expansion also causes the flow to stop, reverse for a mere instant, then continue, a sequence which results in a pulsating flow and consequent pulses in pressure.

The staged ignition of propellants in the preburners and main combustion chamber also triggers increases in pressure, and the gradual release of oxidizer to these chambers must be timed so these increases coincide with the dips in pressure from the oscillating fuel flow; otherwise, the components would be exposed to damaging spikes in temperature.

Once the main fuel valve starts to open, the three oxidizer valves receive a series of position commands to prime the fuel, main, and oxidizer combustors at one-tenth second intervals.

The panel's conclusions, issued in March 1978, called for further testing of both turbopumps and complete engines, and recommended minor design changes. NASA was expecting to launch the first shuttle mission in June 1979, but the report recommended delaying this launch, "to provide leeway" for unforeseen changes. Nonetheless, the reviewers—including Mulready—found no basic flaw within either the SSME itself or the program management.



BOEING/ROCKETDYNE PROPULSION AND POWER

In 1979, as the program approached what was called "preliminary flight certification"—a series of tests that would certify the engine configuration for 10 missions—Thompson remembers a "change in test philosophy."

"As we approached the ground certification program," he says, "we had evidence under a microscope [of] developing cracks in turbine blades as well as some of the bearings [after tests]. We were faced with trying to develop turbine blades that would take decades to achieve. We decided instead to prove to ourselves that even though flaws would develop during the mission, the design would be robust enough to survive. We ran tests—intentionally—with cracks in turbine blades, cracks in bear-


NASA VIA DENNIS R. JENKINS

*NASA technicians use a modified commercial forklift to install the 7,000-pound engines in the orbiter. Components are still being developed to ensure the reliability of the space shuttle's engines and are still being tested almost daily at the Stennis Space Center (opposite).*

ings, to make sure we understood how much margin we had."

The engines completed flight certification between June 1979 and March 1981. Two engines were required to complete two cycles each of 13 tests and 5,000 seconds. In doing so, the program hit another milestone: an overall test life of 65,000 seconds.

The next big test would come on April 12, 1981, when John Young and Robert Crippen took *Columbia* into orbit.

"I didn't know I could hold my breath for that long," Joe Stangeland jokes about the first shuttle launch. He remembers watching the liftoff. "You got so many years of emotion built into this thing," he says. "And the solids separate—and that's just the beginning of the ride as far as the main engines go—and I'm still holding my breath. I teared up and at main engine cut off, I started crying like a kid. My wife was embarrassed. Then she looked around and noticed everybody else was doing the same thing. You were kissing people you didn't even know. I get choked up now just thinking about it."

Mission STS-1 was a triumphant milestone for the SSME development team, but it was just that, a milestone. Afterward, everybody got back to work.

Program managers wanted the additional thrust for heavier payloads, and they wanted a reserve of power for use in emergencies. If at some point in the vehicle's ascent an engine were to fail in flight, managers wanted the remaining two engines to be able to produce 512,000 pounds of thrust each, 109 percent of the rated 470,000 pounds of thrust. None of the four standard abort scenarios—return to launch site, abort to orbit, abort after a single orbit, or transatlantic landing—requires that much additional performance. But the determination was made that in certain rare circumstances, having the extra thrust would be the best way to save lives.

The same shuttle test engines that had run for 65,000 seconds before STS-1 spent little more than a thousand of those seconds at 109 percent power. "We felt like we should at least demonstrate that we could do it without the engine blowing up," says Rocketdyne's Robert Biggs. "But we tested very little at 109 percent before the first flight. The reason was obvious: We didn't want an engine to blow at 109 percent a month before first flight."

Following the success of the earliest shuttle missions, the philosophy became, according to Thompson, "to push the engine almost right to the limit." The engineers ran a number of tests at 109, and Biggs recalls that "we had three engines lost directly at 109, and two lost due to damage accumulated at 109. It was so bad that we declared a moratorium on 109 percent testing. We stopped blowing up engines at 109 because we stopped testing at 109."

Not until after the January 1986 *Challenger* disaster were the engineers at Rocketdyne able to test a new configuration that would provide additional power without stressing the engine components. In the wake of the accident, NASA received a flood of federal funds with which to cure the shuttle's deficiencies, and Rocketdyne changed the SSME by slightly increasing the diameter of its throat, the narrowest part of the rocket nozzle.

In September 1988, a new, one-of-a-kind engine, nicknamed Big Throat, started tests at the Stennis center. The larger throat—10.9 inches instead of 10.3—reduced the engine's pressure, thereby diminishing the strain on its turbopumps. The lower pressure would have resulted in lower performance and loss of payload had the designers not made further revisions. The original engine used small cavities in the combustion chambers to damp potential combustion instabilities, which could seriously damage an engine. The cavities, "stability enhancers," were cooled by liquid hydrogen. With these features removed, the engine could burn the coolant and make up for the performance lost by the lower pressures. The tests at Stennis, therefore, were directed toward demonstrating stable combustion.

To try to produce instability, engineers mounted small explosive charges within the combustion chamber. In eight tests, the explosives failed to disrupt the engine's smooth operation. Instrument readings showed that they produced nothing more than momentary disturbances, which died out in less than a hundredth of a second.

During the first five flights of the shuttle, in 1981 and 1982, the engines operated at full rated power but went no higher. Beginning with the sixth flight in 1983, they routinely

reached 104 percent. John Plowden, Boeing/Rocketdyne's SSME program manager, notes that when Big Throat runs at this level, "it thinks it's running at 100 percent. At 109 percent, it thinks it's at 104 percent." Tests at 109 are now common, while the added margin in the design even permits runs at 111 percent for as long as 400 seconds.

Big Throat, which made its first flight in January 1998, is only one of a number of improvements that are bringing the SSME to its definitive form. Pratt & Whitney is building new turbopumps that offer long life. The first of them, an oxygen pump, made its initial flight in July 1995 and was mounted to a standard (small throat) engine. The company's fuel turbopump is slated to fly next spring.

At a brand-new facility at the Kennedy Space Center, Boeing/Rocketdyne employees inspect engines after every flight. Their inventory of 15 engines includes standard narrow-throat types built entirely by Rocketdyne, standard versions with new Pratt & Whitney turbopumps, and a few Big Throat versions. "We fly all three configurations; we can mix 'em," says Plowden. "We fly 'em as we have 'em."

Dan Hausman, a Boeing/Rocketdyne manager at the Kennedy Space Center who is in charge of ensuring that engines are ready for launch, says each engine has a unique signature that the performance analysis people recognize and track. "The particular performance characteristics of an engine can be identified in terms of its operating temperatures, how it responds to throttling," he says.

None of the engines has ever reached the 55-mission goal that NASA specified in 1973. Even Big Throat engines with new, improved turbopumps—prosaically referred to as Block II—probably never will. The engines can do it: They have already demonstrated 130 starts in ground tests at Stennis. But the most used flight engine, Number 2019, has flown on only 18 missions. Block II engines will be certified for 30.

At this point, it is worth noting that in the two decades since the first flight in 1981, the entire shuttle fleet has flown fewer than a hundred missions. An individual orbiter, such as *Atlantis*, flies perhaps twice a year. By contrast, engine tests in Mississippi take place almost every day, leading to demonstrated longevities that vastly outstrip the demands of the shuttle's flight schedule. This raises a question: With today's shuttle flying no more than eight times in a good year, how much life does its engine really need?

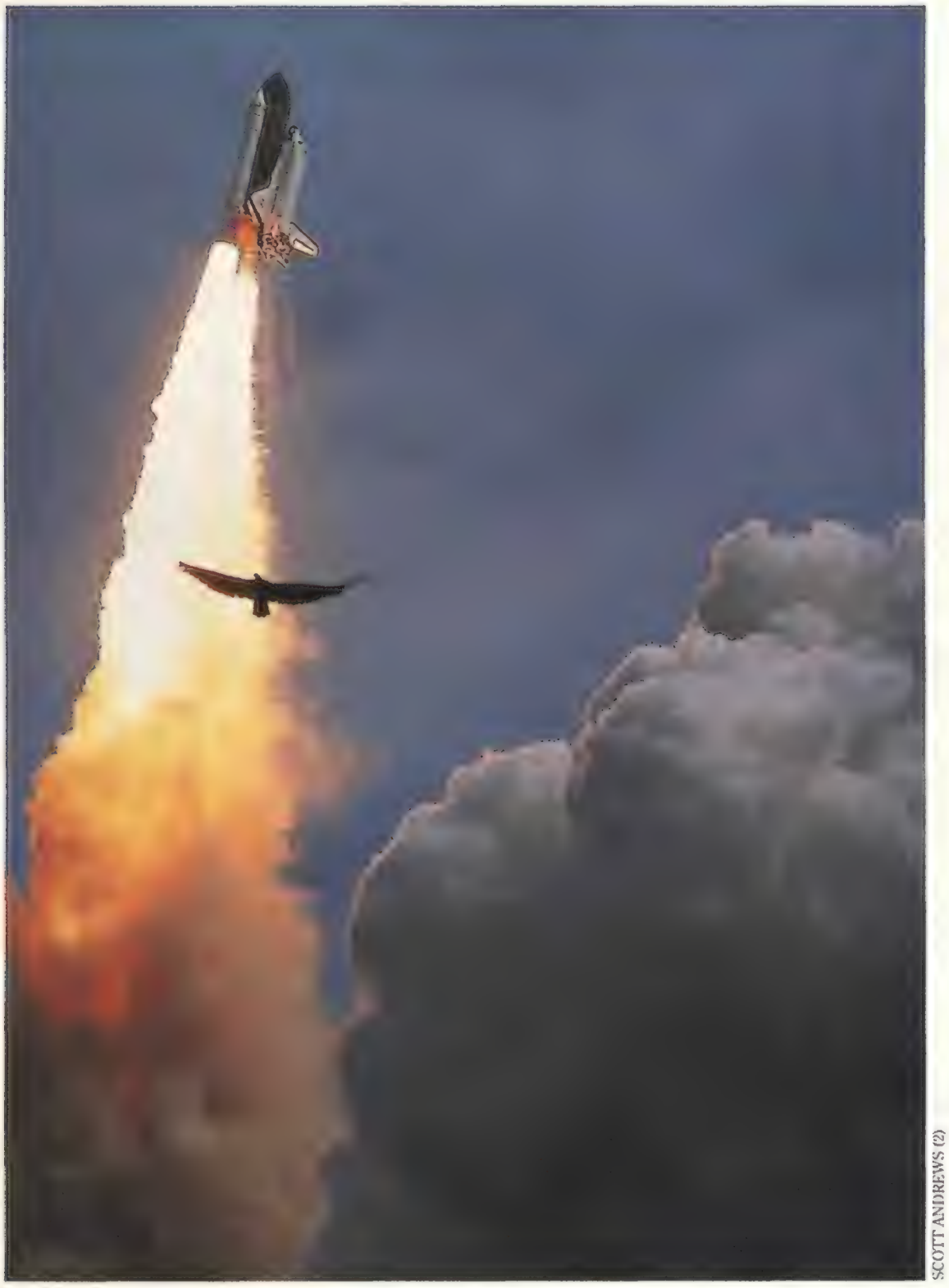
"Testing is very expensive," notes George Hopson, NASA's SSME manager at Marshall. "Given the shuttle's flight rate, it doesn't buy us a whole lot" to push engine life beyond 30 flights. Such a life, properly certified, will easily accommodate demands of the shuttle program for decades to come, "way out past many of our careers," in Hopson's words.

On July 29, 1985, an onboard computer shut down one of the shuttle's main engines six minutes into the ascent on Mission 51-F. The remaining two engines were throttled up and fired for an additional 70 seconds to provide enough energy to reach orbit. Postflight analysis revealed that one of the hot gas temperature sensors had indicated that the failed engine's fuel pump was running too hot when it was not. Rocketdyne modified and replaced the sensors.

This is the only time an engine has shut down after launch and before the shuttle reached orbital velocity, and, when it happened, the other two engines took over just as they had been designed to do. But what if that engine had shut down earlier? What if two engines had failed? NASA has made plans for such contingencies, but critics have questioned whether some of these plans are achievable. Even some astronauts have wondered whether the space shuttle could execute the maneuvers required to return it to the launch site in one of the abort scenarios for which they train. Rocketdyne engineers derive enormous satisfaction from the fact that, as the shuttle approaches its 100-mission mark, NASA has never had to find out.

NASA STENNIS SPACE CENTER

CAROLINE SHEEN



SCOTT ANDREWS (2)

# >SIGHTINGS<

"Remote photography has always been my passion," says Scott Andrews of Nikon. Andrews has photographed ordnance explosions, building demolitions, sporting events, and presidential inaugurations, but he says his most challenging assignments have been manned space launches.

Since photographers can get no closer than 3.5 miles to a shuttle launch at Kennedy Space Center in Florida, remote cameras must stand in. They are primarily triggered by the sound, vibration, or light from the shuttle engines. NASA requires that cameras be in place at least a day ahead of a launch; they also need to be set to accommodate changing light levels and weather as well as curious animals. If a launch is rescheduled, cameras may remain in place for days. Such requirements have resulted in a number of imaginative arrangements to protect equipment from the elements, wildlife, and shuttle exhaust (above).

Andrews caught main engine ignition of *Atlantis* on mission STS-79, on September 16, 1996 (opposite); when photographing *Endeavour* on STS-69, on September 7, 1995 (left), wildlife was a highlight. "The bird just happened to present itself to the camera as *Endeavour* roared past," says Andrews. "I had adjusted my trigger to delay the firing of the camera until the shuttle was high in the air; otherwise, the fast-firing camera would have been out of film."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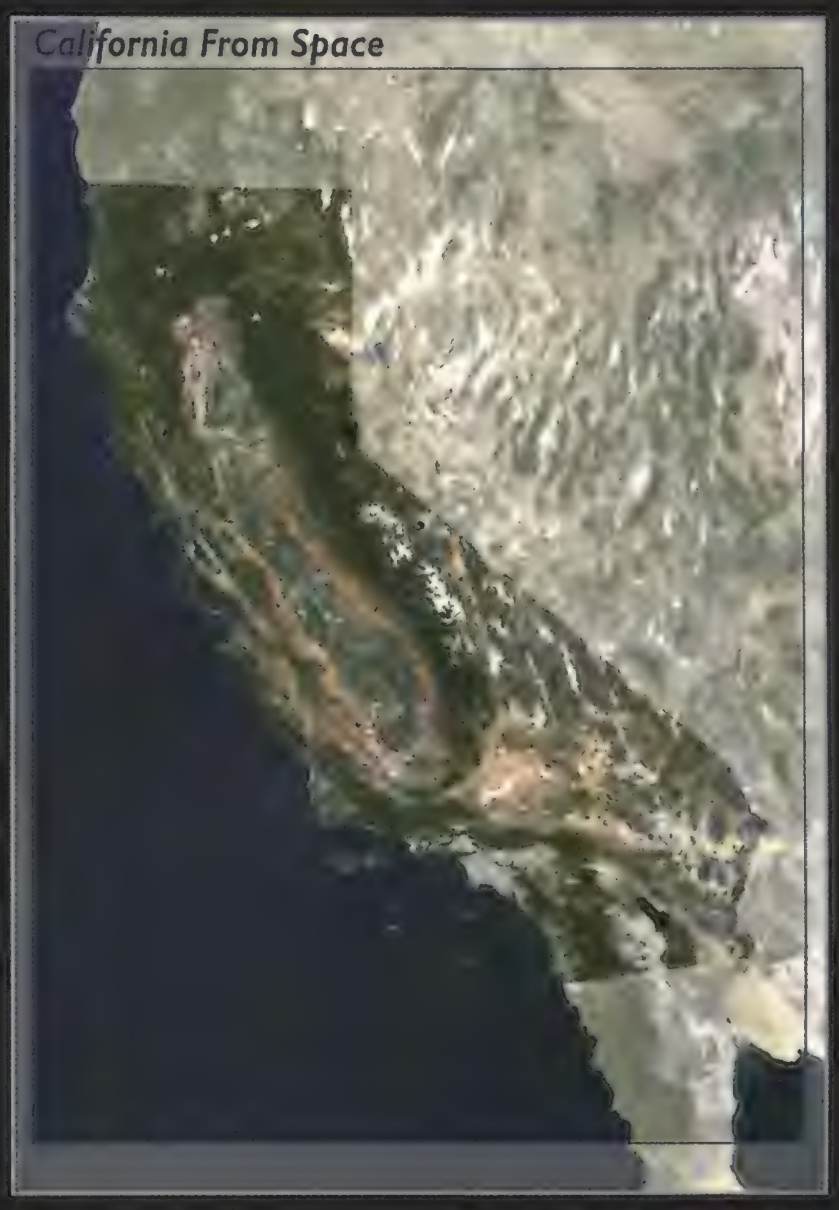


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# A Life Less Ordinary

NASM

**Pancho: The Biography of Florence Lowe Barnes** *by Barbara Hunter Schultz. Little Buttes Publishing Co., 1966; second printing, 1998. 243 pp., $14.95 (paperback).*

Anyone who saw the 1982 film version of Tom Wolfe's *The Right Stuff* has caught a glimpse of the flamboyant character Pancho Barnes. On film as in life, she was the tough, affectionate dame behind the bar of the Happy Bottom Riding Club, a dusty tavern frequented by test pilots from nearby Edwards Air Force Base. Biographer Barbara Hunter Schultz tracked down the details that tell the whole amazing story of Pancho Barnes; more than just a post-World War II bartender, she was by turns a rebellious teenager, a society wife, an expert horsewoman, a "speed queen" of early aviation, a movie stunt double, a popular hostess, a successful rancher, even a published songwriter. These successes, along with unending charity, used up the energy she might otherwise have directed toward domestic ends: She married and divorced four times and only in later life became a responsible mother to her child.

The book opens on August 4, 1930, as Pancho tries to break Amelia Earhart's month-old speed record, 181.18 mph. The challenge is successful: She attains 197.26 mph in her Travel Air Model R. Then Schultz drops back to the beginning of Pancho's life. Born into a wealthy Pasadena, California family in 1901, young Florence Lowe took seriously her grandfather's warning, "Fear can be a dangerous thing," and became too wild to handle. After her only sibling died when Florence was 12, she bounced between boarding schools and ran away on horseback to Tijuana at age 15. At 19 she consented to an arranged marriage to a quiet clergyman named Rankin Barnes, soon bore a son, and then took off to Mexico in search of adventure. It was during a thousand-mile trek to escape political violence there that Florence first became known by the name Pancho.

To combat the boredom of her marriage, Pancho began training horses for the movies. In 1928 she learned to fly, and soon channeled her passion for thrills into a decade of aerial escapades: She founded the barnstorming Pancho Barnes Mystery Circus of the Air, set several cross-country speed records, and worked commercially as a transport pilot and as the first female stunt pilot in Hollywood.

Money troubles and then World War II cramped her flying life, so Pancho settled in the California desert; her Rancho Oro Verde (Green Gold Ranch) grew into a fly-in social club with so many extras that it was finally made off-limits to officers from nearby Edwards. Her later years saw legal and mental problems; she died in 1975.

The book's editors, unfortunately, let slip some appalling grammatical and punctuation errors. But aside from that, Schultz's fascinating account of Pancho Barnes is worth owning: It balances all facets of her life. Schultz doesn't place undue emphasis on the flying years, but does credit Pancho with "pushing the envelope" of early aircraft performance standards.

*—Nan Chase is a freelance writer based in Boone, North Carolina.*

**The Horten Brothers and Their All-Wing Aircraft** *by David Myhra. Schiffer, 1998. 320 pp., b&w photos and drawings, $59.95 (hardcover).*

If its fuselage, tail, and engine nacelles contribute nothing to an aircraft's lift, why not get rid of them?

From the first decade of powered flight, designers have pursued the all-wing dream, notably Jack Northrop in the United States and the Horten brothers in Germany. Reimar and Walter Horten were a step ahead, testing an all-wing sailplane in 1933, a twin-engine pusher in 1937, and a turbojet fighter-bomber in 1944. When World War II ended, Reimar was working on a six-engine "Amerika

Bomber" that was designed to carry a hypothetical atomic bomb all the way to New York City.

After the war, the Western Allies dismissed their work, though the British toyed with a transport version of the Amerika. Walter stayed in Germany and eventually rejoined the Luftwaffe; Reimar went to Argentina and worked for the Peron government. Meanwhile, Jack Northrop continued to try to build an all-wing turbojet bomber (see "The Edwards Diaries," June/July 1997). That he never hired the Hortens, while German engineers were recruited for the U.S. space program, may have been one of history's great missed opportunities.


In the end, all that came from the brothers' work were a dozen aircraft whose beauty still astonishes—that's especially true of the bat-like Ho 229, which wouldn't look out of place at a 21st century airshow or combat airfield.

David Myhra wrote his book several years ago, while both Hortens were alive, and he approached it as their friendly ghost, rather than a dispassionate historian. The writing is sometimes clumsy and typographical errors are rampant, like the misdating of the first flight of the Ho 1 sailplane—perhaps the most important fact in the book—by a year. There are 700 photos, sometimes duplicative but always fascinating. (My favorite shows the Horten dining room in Bonn, with an aircraft wing entering the doorway and extending across the table, which is set for dinner.) An appendix provides three-views of 60 design variations, but without the dates and dimensions that would allow the reader to compare one with another, or with the contemporaneous designs of Jack Northrop.

All praise to David Myhra for writing this book, and to Schiffer for publishing it. What a pity they didn't hire a good editor while they were at it.

*—Daniel Ford wrote* Glen Edwards: A Bomber Pilot's Diary, *forthcoming from Smithsonian Institution Press.*

**Clipped Wings: The Rise and Fall of the Women Airforce Service Pilots of World War II** *by Molly Merryman. New York University Press, 1997. 237 pp., $29.95 (hardcover).*

The best-known women aviators of the second world war were the Women Airforce Service Pilots, who served with, but not in, the Army Air Forces. From September 1942 until December 1944, more than a thousand American women flew as civilian auxiliary pilots, testing and ferrying military aircraft and towing targets. In all, the WASPs flew more than 60 million air miles, ferried 12,650 aircraft of 77 types, and had a lower accident rate than male pilots. Despite this excellent record, they were closed down even before the war ended, and only received military veteran status in the 1970s.

*Clipped Wings* is not a history of the WASPs; instead, it uses them as a case study to examine American culture and beliefs about what roles women and men should play during and after war.

Molly Merryman sees the WASPs as unique among the women's service groups. Unlike the Women's Army Corps, the WASPs were denied formal induction into the military during the war; Merryman wants to know why. She refuses to accept the usual explanation: that the women pilots simply weren't needed anymore.

Unlike other women, the WASPs took on an elite military role—that of pilot. Women in other services were employed in less prized duties traditionally associated with women—administration, clerical, supply. Thus, Merryman believes, the WASPs "directly challenged assumptions of male supremacy in wartime culture." She believes the personality conflicts between WASP director Jacqueline Cochran and others have been greatly exaggerated. The real struggle was in the media, where WASP images varied wildly according to public opinion, and on the floor of Congress, where decisions were based on social pressures rather than military necessity.

## THE FRIENDLY SKIES

**Your Flight Questions Answered by a Jetliner Pilot** *by John Cronin. Plymouth Press (1-800-350-1007), 1998. 112 pp., b&w photos and illustrations, $9.95 (paperback).*

In a small book that will educate both white-knuckle fliers and those who fight for the window seat, John Cronin strips some of the mystery from your next experience with stale peanuts and lost baggage. Speaking of baggage, there's an explanation of where it goes and what happens to it in transit, as well as lessons on subjects such as basic flight principles, how airliners are routed by air traffic control, how flight crews avoid bad weather, and how pilots are trained.

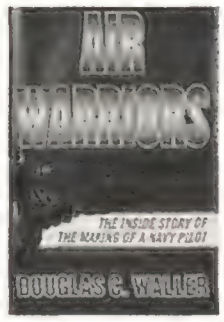
For example, Merryman examines in detail the Ramspeck Report, which opposed WASP militarization; the report claimed that WASP training was prohibitively expensive and that WASP admission standards had been dangerously lowered. In fact, Merryman notes, costs were actually comparable to those incurred training male pilots, and standards were always higher than those required of men. Despite the testimony of military leaders like General Hap Arnold (who provided strong data in support of the WASPs), the Ramspeck Report and media opinion pieces swayed the vote against WASP militarization.

The book, an expansion of Merryman's doctoral dissertation, is loaded with jargon like "cultural constructions of gender identity." It does not provide a full history, and contains little information on attitudes within the military itself. Its strongest contribution is an interesting new theoretical analysis of gender integration in the military in a broad social context.

*—Reina Pennington is a former Air Force intelligence officer and a Ph.D. candidate studying the history of military women.*

**Air Warriors: The Inside Story of the Making of a Navy Pilot** *by Douglas C. Waller. Simon & Schuster, 1998. 416 pp., b&w photos, $25.00 (hardcover).*

Over a period of almost two years in the mid-1990s, during the post-Tailhook era, the author lived and flew with a group of young men and women as they underwent flight training at Pensacola, Florida—"the cradle of Naval Aviation"—and at the El Centro Naval Air Facility in the Southern California desert. In the process, he interviewed more than 200 aviators from every segment of the naval aviation community. He also experienced the same training flights, exercises, and drills as the regular students, except the one final, dreaded rite of passage—landing on an aircraft carrier at night, or "practice bleeding," as some Naval aviators call it.




We learn early on that check flights at key milestones in the flight syllabus are the measure of success or failure for the students. A few "downs," or unsatisfactory flight checks, along the way often put an early end to a budding career as a naval aviator. Marginal performance in some

phase of flight training can often mean the difference between future assignment to a coveted aircraft carrier squadron or less glamorous (but equally essential) land-based patrol aircraft or helicopter unit.

In what could serve as a primer for anyone who wants to know what U.S. Navy flight training is all about, the author explores in minute detail every facet of the process, from the rudiments of the most basic airplane maneuvers to advanced tactics such as dive bombing, close air support, and air combat maneuvering, or dogfighting. Each evolution is described in excruciating detail, which can be of interest to a very knowledgeable reader intent on catching a technical error (of which there are a number). But an average aviation buff may find that 40 pages devoted to every maneuver in a single dogfight can be confusing and distracting.

Notwithstanding the excessive detail, there is an aspect of the book that makes it of more than passing interest to readers concerned with the 1990s generation. In remarkable fashion, Waller has managed to get inside the heads of his protagonists: He has probed their psyches and reveals all of their concerns, fears of failure, joys of success, expectations, and ambitions. The result is a rare insight into a group of young men and women who are the "cream of the crop," the overachievers and the competitors, all of whom share "a cockiness nurtured by the danger and excitement of their profession."

Thanks to the unusual candor and openness of the principal characters, the reader may find him- or herself gradually becoming emotionally involved as the aviators navigate through pitfalls and obstacles toward their ultimate goal—winning Navy wings of gold.

*—Tim Wooldridge is a former Naval aviator and an aviation historian at the National Air and Space Museum.*

**Bogeys and Bandits: The Making of a Fighter Pilot** *by Robert Gandt. Viking Penguin, 1997 (paperback edition published 1998). 324 pp., $22.95.*

After a Naval aviator wins his or her coveted wings, the next phase of training takes place in the RAG, or Replacement Air Group, a holdover term despite the more current name, FRS—Fleet Replacement Squadron. Robert Gandt follows students enrolled in what was once one of three F/A-18 RAGs in the Navy—where new strike pilots learn their craft.

Despite his background as a former Naval aviator, Gandt takes on the role of reporter—we hear no judgmental "been there, done that" tone. He has nothing but admiration for the aviators in class 2-95, and candidly admits that many are of higher academic caliber than the pilots of his generation—those trained during Vietnam and the cold war, when the military services required a more steady stream of trainees.

We get to know the personalities quite intimately. Among others, there is Ilya "Road" Ammons, grandson of a Tuskegee Airman, Chip Van Doren, a studious techno-geek who retains information about the F/A-18 like a hard drive, and J.J. Quinn, already an experienced Marine Corps helicopter pilot who gets his chance to transition to fighters. There are two females in the bunch, Sally "Shrike" Hopkins, who has an extremely prominent chip on her shoulder, and Angie "Rambo" Morales, who becomes one of the boys.


We share their heartbreaking struggles: Quinn facing a review board after a string of unsatisfactory marks in training, Ammons sweating his first real setback, a failure to achieve carrier qualification on his first attempt while his classmates all make the grade. And the entire class experiences tragedy when a classmate is killed while practicing carrier approaches on land.

Overlook the occasional overheated passage, like a description of a downed Iraqi fighter pilot during the Gulf War "keeping an appointment with Allah." This is a good tale, made even better because it's true.

*—John Sotham is an associate editor of* Air & Space.

**ON CD**

**Russians in Space: 40th Anniversary of Sputnik Special Edition.** *Compact Book Publishing in association with The Ultimax Group, 1997. $29.95 plus $3.50 shipping and handling.*


This nicely packaged retrospective features Soviet and Russian space achievements, from Sputnik to the Mir space station. The material on the disc is arranged in four basic categories: key designers and cosmonauts, major programs, technology, and a module that explains the basics of the solar system and space science.

**North American Aircraft 1934—1998, Volume 1** *by Norm Avery. Narkiewicz//Thompson (call 714-542-7145 to order), 1998. 204 pp., color and b&w photos, $35.95 (paperback).*

This is the fourth in a series of superb books that combine hundreds of quality photos, informative historical text, and detailed production and performance data on the aircraft produced by Vultee, Martin, and Fairchild. In this one, Norm Avery chronicles how James "Dutch" Kindelberger, chief engineer at Douglas, became president of North American in 1934 and turned a little-known company into a wildly successful producer of 57,000 AT-6/SNJs, B-25 Mitchells, P-51 Mustangs, F-82 Twin Mustangs, F-86 Sabres, Navy FJ Furies, the B-45—the U.S. Air Force's first production jet bomber—and several others.

Volume 2, which brings the North American story up to date with the December 1996 Boeing/Rockwell aquisition, is due out in late 1998.

*—Sam Smith is a commercially licensed pilot and amateur aviation historian.*

## GO FLY A KITE

**The Magnificent Book of Kites** *by Maxwell Eden. Black Dog & Leventhal, 1998. 464 pp.; photos, drawings, and diagrams; $17.98 (hardbound).*

This volume is written for anyone interested in kite building or flying and presents a lot of information at a modest price in a nice package (well,


the black-and-white photographs are sort of muddy, but never mind). If you've ever wondered why kites come in so many goofy shapes, here's your answer—along with about a thousand others that tell you how, why, and what.

Some of the kite designs, complete with instructions for building them, are quite advanced, while others are based on historic or more traditional types, but the strength and durability of modern materials have such advantages that you'll follow the author to the suppliers of plastics, metals, and ripstop nylon, listed in the ample appendices at the back.

*—George C. Larson is the editor of* Air & Space/Smithsonian.

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**Classical Greece at Easter** April 4-17.

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**Christmas Programs: Brandywine Valley, Delaware** (December 4-6). **Savannah, Georgia and Charleston, South Carolina** (December 21-27), **and Quebec City** (December 22-27).

**Wildlife of the Everglades (Florida)** January 9-16.

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**Behind the Scenes at the Metropolitan Opera (New York City)** March 30-April 3.

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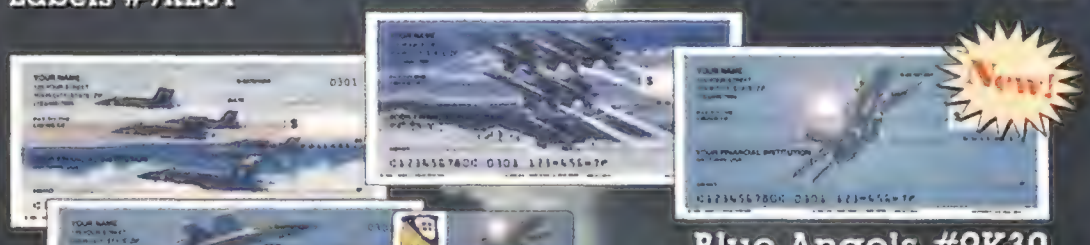

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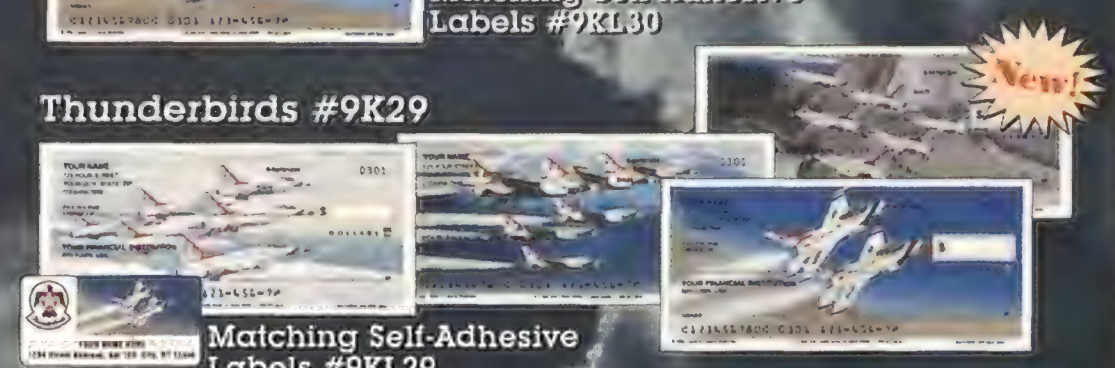

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# CREDITS

**Cover.** Nashville, Tennessee illustrator Harry Whitver has been drawing airplanes and pestering pilots for 30 years.

**The Broad Side of a Barnes Door.** Writer and movie stunt flier Debbie Gary Callier is also an airshow pilot (this year she is flying the Bud Light Microjet).

Charlie Hillard died in April 1996 while landing a Hawker Sea Fury at an Experimental Aircraft Association fly-in at Lakeland, Florida.

**Moonstruck.** Howard E. McCurdy is the author of *Space and the American Imagination* (Smithsonian Institution Press, 1997).

Further information: The Collier video can be obtained from Victoria House Press at (212) 809-9090. The Kaysing book is out of print.

**Extreme Machine.** George C. Larson is the editor of *Air & Space/Smithsonian*.

**Whose Planes Are They, Anyway?** Washington, D.C. writer Carl Hoffman's articles on the salvaging of old aircraft have appeared in various magazines.

**Walk This Way.** Houston-based freelancer David S.F. Portree writes about moon and Mars exploration on the Internet at members.aol.com/dsfportree/explore.htm.

**The Ravens of Long Tieng.** Former Air Force fighter pilot Ralph Wetterhahn flew combat missions in Vietnam.

Further reading: *The Ravens: The Men Who Flew in America's Secret War in Laos*, Christopher Robbins, Crown, 1987.

*Sky Is Falling*, Gayle Morrison, McFarland & Co. (forthcoming this year).

**What I Learned at Kitplane Camp.** Since returning from camp, Phil Scott has occasionally felt like building an airplane, but the urge passes when he watches anything hosted by Bob Vila.

**Back on the Line.** James R. Chiles did his pilot training in the now-discontinued Cessna 150.

**27,000 Seconds in Hell.** Frequent contributor T.A. Heppenheimer is working on a history of the space shuttle for NASA.

**Australia's Desert Aviary.** Freelance writer Lise Pyles currently lives on one of the old Connellan Airlines runways, now Memorial Avenue.

# CALENDAR

**October 1–4**
Reunion: Eagle Squadrons of the Royal Air Force. Adams-Mark Hotel, Tulsa, OK, (925) 828-0227.

**October 3 & 4**
AirFest '98: Jaxport Celebrates 30 Years in Aviation. Jacksonville, FL, (904) 630-3080.

Chester County Airshow. G.O. Carlson Chester County Airport, Coatesville, PA, (610) 384-9000.

**October 8–11**
Reunion: Air Commando Association. Howard Johnson Hotel, Fort Walton Beach, FL, (850) 581-0099.

**October 10**
"Thunder in the Sky" Auburn Air Fair. Auburn, CA, (530) 878-9496.

**October 10 & 11**
International Airshow. Alliance Airport, Fort Worth, TX, (817) 551-1967.

**October 17 & 18**
Harriet Quimby Research Conference. Kalamazoo, MI, (616) 387-4641.

**October 22–24**
Reunion: Silver Wings Fraternity. Furama Hotel, Los Angeles, CA, (800) 554-1437.

**October 24**
Program on the Battle for Leyte Gulf during World War II and a flyby of a Grumman TBM Avenger. Palm Springs Air Museum, Palm Springs, CA, (760) 778-6262.

**October 29–November 1**
Reunion: 318th Fighter Interceptor Squadron, Scottsdale, AZ, (602) 838-2444.

*Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar,* Air & Space/Smithsonian, *901 D St. SW, 10th Floor, Washington DC 20024; fax: (202) 287-3163. Events will be listed as space allows.*

## ON THE WEB SITE

# V-22: Nose to Tail

For more on the capabilities of the world's first operational hybrid aircraft and on the creative engineering that produced it, visit the Web at:

**www.airspacemag.com/ASM/mag/supp/ON98/Osprey.html**

# LOOKING AT LAOS

VIETNAM MEMOIR

A gallery of photographs showing life at the CIA's secret base at Long Tieng during the Vietnam War appears at:

**www.airspacemag.com/ASM/mag/supp/ON98/Ravens.html**

## FORECAST

## *In the Wings...*

**Inventing the Spyplanes.** Nothing like them had flown before. *Deep Black* author William Burrows explains how wings, cameras, actuators, engines—almost all systems on the U-2 and SR-71—were created from scratch.

**Solar System Sampler.** Chunks of asteroid and cosmic dust are coming soon to a lab near you.

**Aviation's Bad Boys.** "Real pilots don't fly ultralights." Find out why them's fightin' words to a growing group of ultralight ultra-fans.

**The Death of the CNAC.** When Mao won in China, the American founder of the China National Aviation Corporation had to choose between his country and his passion.

**"Hello, Mir? The Cowboys Won!"** Sports scores, Christmas greetings, news from home, heart-to-hearts—when space station residents aren't getting what they want from mission control, they simply tune in to ham radio.


JOHN HEINLY

# Australia's Desert Aviary

In the Outback town of Alice Springs, eucalyptus trees waft a scent of cough drops over Memorial Avenue. The street is quiet except for the squawks of galahs, cockatoos that adorn the telephone wires like pink and gray beads on a string. The desert heat tempts visitors to bypass the Central Australian Aviation Museum, housed in an old hangar, and head for air conditioning. But in the pursuit of something good, sometimes sweat is required. Surely E.J. Connellan, whose name is synonymous with Outback aviation, believed that.

"E.J. was easygoing and brilliant—lovely bloke," remembers museum historian Perry Morey, nodding toward a display honoring his longtime friend and employer. In 1938, Connellan, pilot and would-be cattleman, got a job surveying the Northern Territory for the government of Australia. Flying *Fanny*, his Spartan biplane, Connellan got a good look at some of the world's bleakest terrain. He realized that the only way mining and cattle workers in the Outback could get mail and supplies was from undependable truck or camel caravans. The Australian desert badly needed air service. The following year, Connellan answered the call.

Connellan Airways began with a mail contract and two Percival Gull VI monoplanes. The first hangar was a simple affair: The flooring was made from busted-up termite hills (the building is now the museum, and the floor has been replaced by concrete). Connellan himself leveled runways by pulling iron wagon-wheel rims behind his 1920 Rolls-Royce Silver Ghost.

Over the next 40 years the airline grew, linking 132 remote communities (a sun-bleached map in the museum depicts the routes). Besides transporting mail, medicine, and doctors, Connellan promoted tourism. Along with Morey's father, he organized Wildman Safari Camp: Connellan delivered rich Americans in his six-seat Rapide, and Morey's father hosted a buffalo and crocodile hunt.

Connellan's enterprises were not appreciated by all. One Alice citizen complained that Connellan's routes, which passed over her outhouse, invaded her privacy. To reassure her, Connellan reportedly offered to have her fly over while he sat in her dunny (she declined).

In 1968 Connellan Airways moved to a larger airport in Alice Springs and subsequently became Connair. Recalling Hollywood's explosive *Conair*, the name now seems grimly prophetic. In 1977, a pilot who'd been sacked stole an airplane and flew kamikaze-style into the Connair offices, killing Connellan's son and three co-workers. Connellan soon sold the crippled airline to East-West Airlines, which later folded. The air services were absorbed by the carrier Ansett. An era of Australian aviation had ended.

*Central Australian Aviation Museum, Memorial Ave., Alice Springs, NT, Australia, 0870. Phone (61) 889-515686. Open Mon.–Fri., 9 a.m.–5 p.m., and Sat. and Sun., 10 a.m.–5 p.m. Admission free.*

To document the airline's history, the museum displays examples of the Connellan fleet, such as a DC-3 (presently being restored) and a 1960s-era Beechcraft D-18S. Though there's no example of those early Percival Gull VIs, the museum does have a Gull follow-on, the P-30 Proctor Z, a wood-and-fabric trainer used in World War II.

The museum also exhibits other aircraft that have served the Outback, including a DHA3 Drover from Australia's Royal Flying Doctor Service and a 1942 Commonwealth Aircraft CA 6 Wackett trainer used by the Royal Australian Air Force. One display shows the rotor from a Bell 47 G2, the first helicopter used for cattle mustering in the region.

A more unexpected artifact is the museum's Rolls-Royce Avon 109 engine, which was used to power Canberra bombers. The engine is displayed to represent one of Alice's most exotic visitors. In the late 1950s, Connellan's radioman reported that a Canberra was coming in to land at the larger Alice Springs airport; then he reportedly exclaimed, "I hear engines spooling down. She's landing *here*!" The bomber, one of the Australian air force fleet, set down on Connellan's 1,000-yard dirt runway, which was completely rutted and marked with a white cross. "Even a junior pilot knows that means it's unserviceable," says Morey. The next day the bomber was towed onto the other runway, which students swept free of kangaroo droppings and pebbles. Eventually the Canberra took off, leaving the town to ponder the mysterious stopover.

The museum's greatest historical nugget is the Westland Widgeon *Kookaburra*, lost for 50 years in the Tanami Desert. It was flown as part of a search party looking for Charles Kingsford Smith—Australia's Lindbergh—who disappeared in 1929 while attempting an Australia-to-England flight. Smith was found, but *Kookaburra*'s pilot and engineer, who had landed in a small clearing to fix a loose tappet and couldn't take off again, perished. The loss caused public fury, which was fanned when Smith casually remarked that while awaiting rescue he'd enjoyed brandied coffee. Smith's disappearance was denounced as a publicity stunt, and a formal inquiry into "the Coffee Royal Incident" followed. The aviation pioneer was exonerated but public opinion wavered. *Kookaburra*, reclaimed from the sand after half a century, today rests in a re-created desert setting in its own building, near the place from which it had last taken off.

Before rushing off for a cold drink, departing visitors should pause at the cemetery next door. Connellan died a retired cattle station owner in 1983, but his grave is marked by a symbol of his first great venture. Reflecting harsh sun off its blades, the propeller reminds us of what he gave to Outback aviation: 40 years of service and dedication—40 years of sweat.

*—Lise Pyles*

# CONFIDENCE IS HIGH

Virgin INTERACTIVE

F-16 Aggressor is the closest anyone outside the military will get to experiencing flight in the cockpit of an F-16. Selected as one of 1998's "Hot 100" games by both *Computer Gaming World* and *PC Gamer*, F-16 Aggressor boasts a fly-by-wire system that's been modeled and integrated to perfection—a technological feat few if any flight sims can claim.

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World class technology featuring flight modeling so accurate that only top secret military features have been excluded.

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Uniquely detailed enemy A.I. that controls tanks, helicopters, boats, trains and cars with incredible realism.

Engage in up to 4 player simultaneous interactive air combat in target-rich environments over the internet or LAN.

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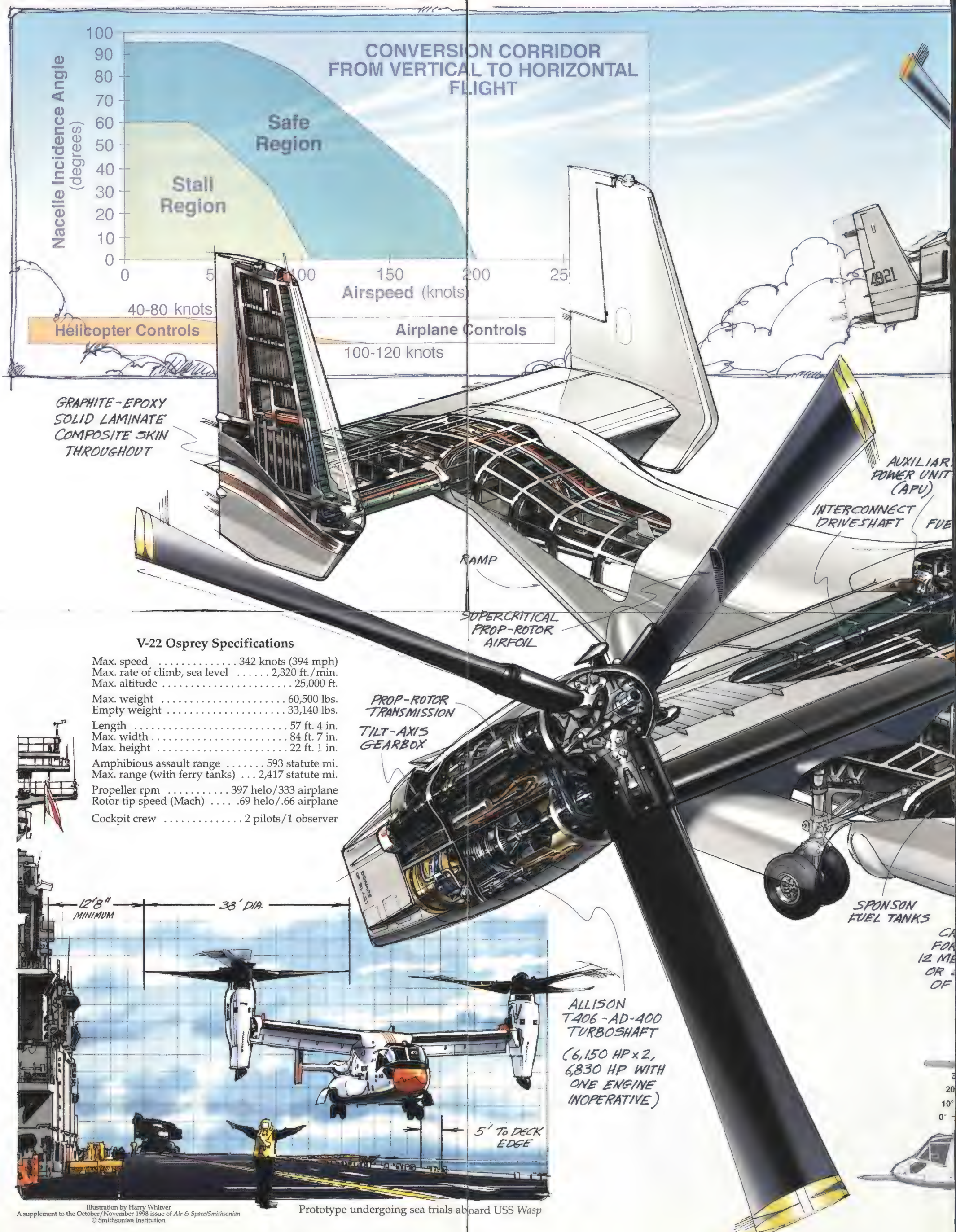



## V-22 Osprey Specifications

| | |
|---|---|
| Max. speed | 342 knots (394 mph) |
| Max. rate of climb, sea level | 2,320 ft./min. |
| Max. altitude | 25,000 ft. |
| Max. weight | 60,500 lbs. |
| Empty weight | 33,140 lbs. |
| Length | 57 ft. 4 in. |
| Max. width | 84 ft. 7 in. |
| Max. height | 22 ft. 1 in. |
| Amphibious assault range | 593 statute mi. |
| Max. range (with ferry tanks) | 2,417 statute mi. |
| Propeller rpm | 397 helo/333 airplane |
| Rotor tip speed (Mach) | .69 helo/.66 airplane |
| Cockpit crew | 2 pilots/1 observer |

Prototype undergoing sea trials aboard USS *Wasp*

Illustration by Harry Whitver
A supplement to the October/November 1998 issue of *Air & Space/Smithsonian*

# V-22 Osprey

## An inside look at the airplane that hovers like a helicopter.

AIR&SPACE
Smithsonian

PENDULUM DAMPERS

COMPOSITE PROP-ROTOR BLADE

CONVERSION ACTUATOR

REFUELING PROBE

WING FENCE

FLAPERONS

WING-STOW FLEXRING

MID-WING GEARBOX

WING TANKS

DE-ICING BOOTS

CAPSTAN DRIVE

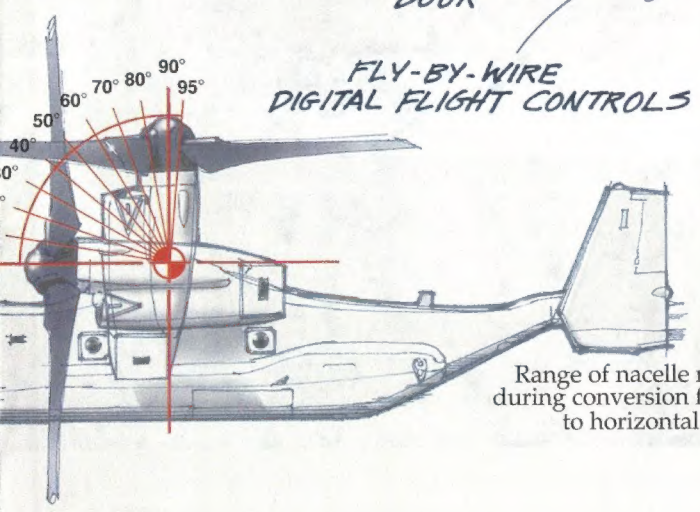
CABIN CAPACITY 25 PEOPLE, MEDICAL LITTERS, 20,000 LBS. CARGO

ROLLER CONVEYOR SYSTEM

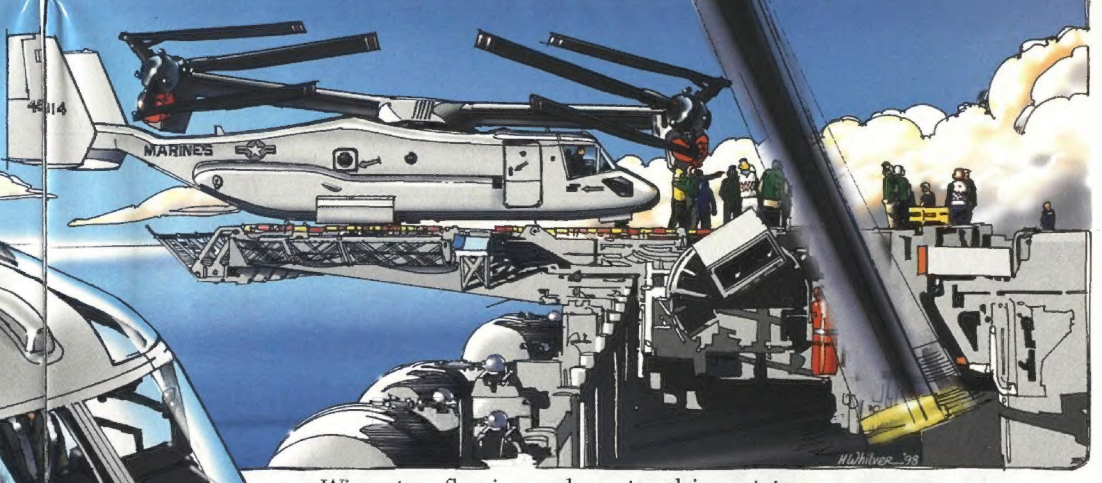
FORWARD DOOR

AVIONICS

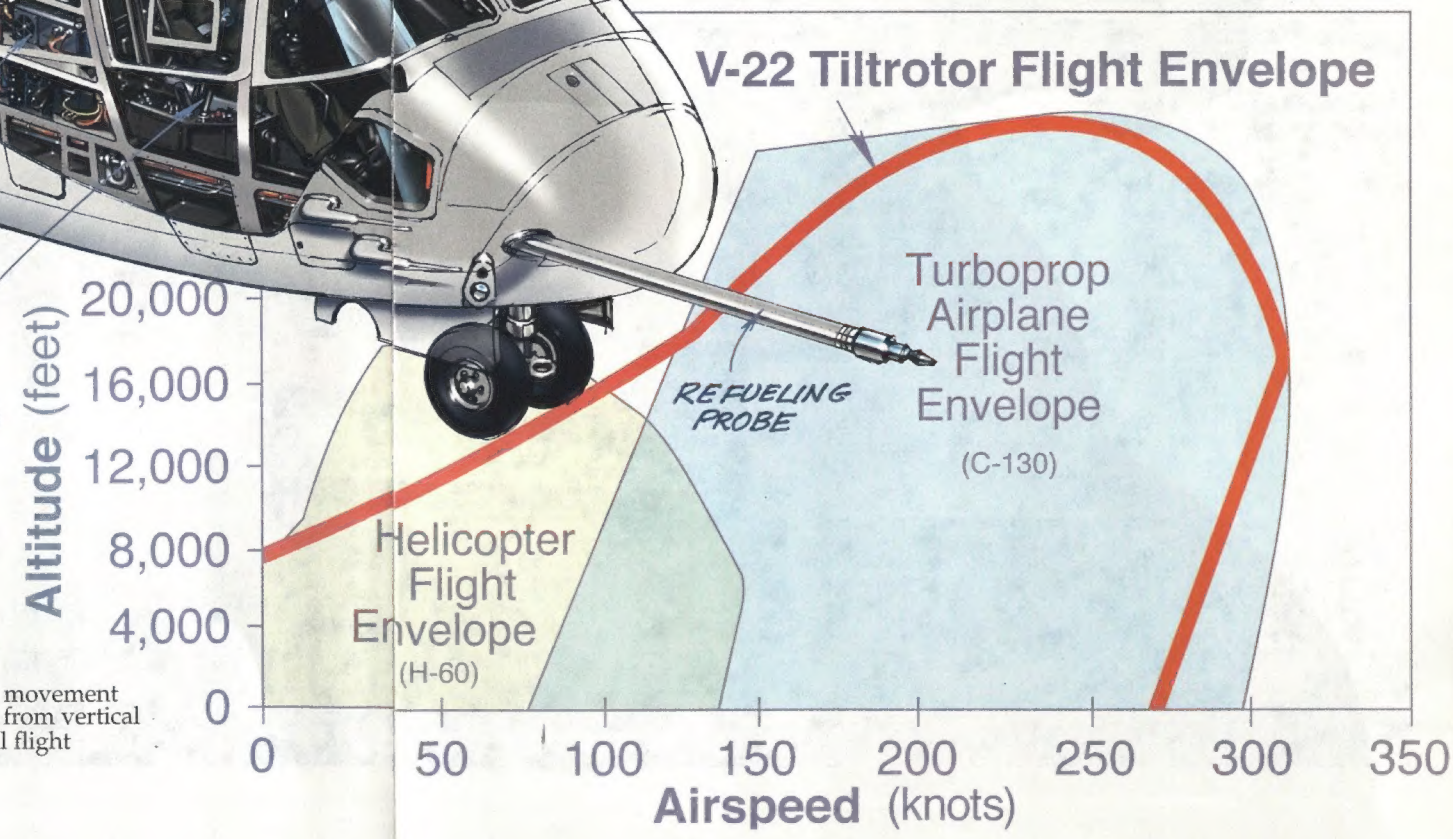
FLY-BY-WIRE DIGITAL FLIGHT CONTROLS




Range of nacelle movement during conversion from vertical to horizontal flight




Wing-stow flexring and capstan drive rotate wing and nacelle assembly for stowage



# Super

Ram The New Dodge

# power.


**IN 1947, WHEN CHUCK YEAGER BECAME THE FIRST MAN TO BREAK THE SOUND BARRIER HE HAD A ROLEX CHRONOMETER ON HIS WRIST.**

**FIFTY YEARS LATER, STILL WEARING A ROLEX, HE DID IT AGAIN.**

At 21, Chuck Yeager led a squadron of fighter pilots in World War II. At 24, he became the first person to fly faster than the speed of sound. And he remains a man on the move. "I don't jump off 15-foot fences anymore," says Yeager, "but I still enjoy flying a high-performance aircraft." And in October 1997 he did just that, breaking the sound barrier in an anniversary flight.

"A pilot has to believe in his equipment. That's why I wear a Rolex," says Yeager. "I wore one when I broke the sound barrier in '47 and I still do today."

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